the glass industry
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GCMI Meets in Phoenix, Arizona

• The Glass Container Manufacturers Institute moved westward this fall to hold its twenty-second meeting at the Arizona Biltmore Hotel, Phoenix, Arizona, November 13, 14 and 15.

In calling the meeting to order, S. B. DeMerell, the Institute's chairman of the board of trustees and vice president, Anchor-Hocking Glass Corporation, voiced the feeling of the assembled members in his opening remarks. He said: "I feel sure that this is going to be one of our best meetings. We have many good business sessions scheduled, as well as many pleasant social activities, and I think we have already sensed the feeling of hospitality for which the West is so justly famous.

Left to right: V. L. Hall, S. B. DeMerell, R. L. Cheney

"All of us, I am sure, are particularly pleased at meeting so many of our west coast friends here in Phoenix, and I know we look forward to the 'Home on the Range' cocktail party at which they will be hosts, preceding the steak fry tonight."

Mr. DeMerell, in his brief address, merely outlined the meeting program and then turned the meeting over for the presentation of reports of the various standing committees.

While all of the committee reports received the earnest attention of the membership, of outstanding interest was the presentation of plans for a million-dollar-plus advertising and promotion campaign defining the advantages of glass packaging for foods, beverages, drugs, cosmetics and other products.

R. L. Cheney, GCMI marketing director, told the membership that an expanded advertising, publicity and promotional drive in 1957 will center around a series of ten full-page, full-color ads in national women's magazines.

These ads will appear in Good Housekeeping, Ladies' Home Journal, McCall's, Family Circle and Woman's Day, with a total of over 32,000,000 readers, Mr. Cheney said. Black and white, as well as color versions will appear in national trade and labor publications and in regional labor papers.

"The campaign will emphasize that glass protects the natural flavor of its contents, lets the housewife see what she is buying, and, in addition, stimulates impulse buying in today's supermarket era," Mr. Cheney declared.

"There has been a steadily mounting preference all over America in recent years for glass-packed products", he said. "This has been reflected in a solid rise in domestic shipments of glass containers. We anticipate even greater gains in 1957."

Kenyon & Eckhardt Inc., is the advertising agency handling the GCMI account.

Of considerable interest and reflecting the increased tempo of the promotional activities of the glass container industry was the talk by C. C. Merrifield, president of The Econometric Institute, Inc., an independent economic consulting organization.

Addressing the membership, Mr. Merrifield estimated that total glass container shipments in 1957 would total 144 million gross. This amounts to 20,736,000,000 units or 124 per capita. It is an increase of four million gross —or three per cent—over the estimated 1956 total.

(*Continued on page* 685)

$Q = AC\sqrt{2gh}$

Precision Glass, Fabrication and Uses

By OSCAR H. GRAUER and
WILLIAM S. CONWAY
Fischer & Porter Company, Hatboro, Pennsylvania

ABSTRACT

Glass is an ideal material for precision uses and is rapidly achieving prominence in precision instrumentation. Precision glass tubing is an important form of precision glass. In its fabrication, problems of reforming, devitrification, annealing, etc. assume critical importance as dimensional tolerances of from ± .001" to ± .0001" have to be met. These close dimensional tolerances in turn furnish the precision to the glass components of instrumentation ranging from simple capillary tubes to a battery of flow meters, controlling the operation of an industrial process.

INTRODUCTION

Although glass has been made by man since antiquity, precision glass has only recently emerged as a regularly manufactured article of commerce.[1] By precision glass is meant glass which has been selected for freedom from defects, which has been fabricated to a given shape with a dimensional tolerance within a few thousandths of an inch, and which has been strain relieved and stabilized by a proper annealing treatment.

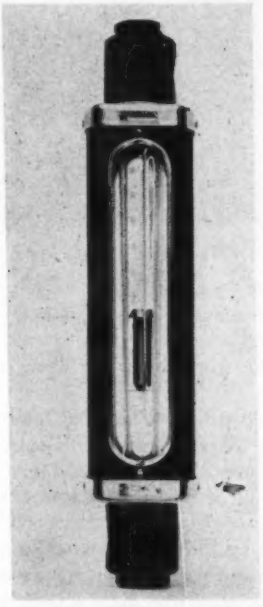
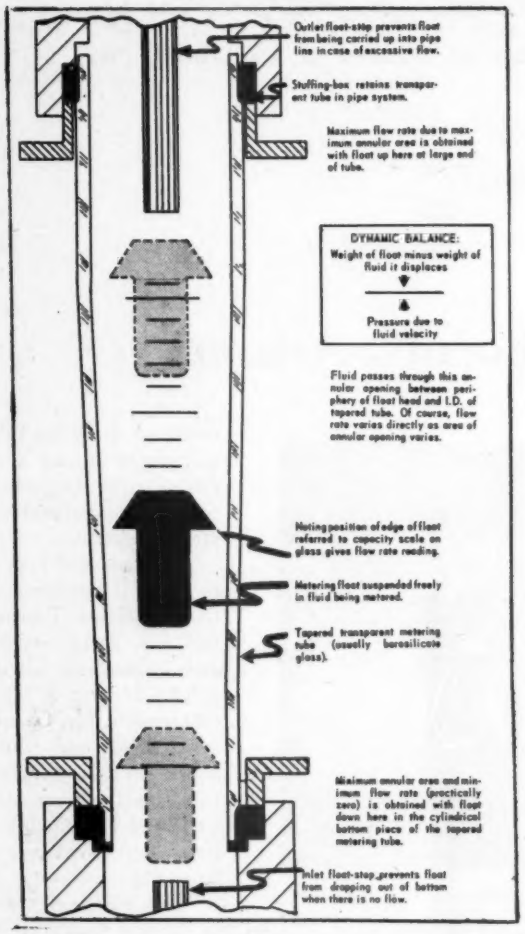


Fig. 1. Variable Area Flowrator with tapered precision bore glass tube component.

An important form of precision glass for industrial use is precision-bore reformed tubing (Fig. 2). This starts as raw glass tubing with an I.D. tolerance of from ± 1/8 in. to ± 1/32 in. This raw glass tubing is positioned around an accurately surfaced mandrel and the air between the mandrel and tube evacuated. The entire assembly is rotated while an air-gas or oxygen-gas flame traverses the length of the tubing, causing it to collapse around the mandrel. During cooling, the mandrel, which has a greater thermal expansion than glass, contracts more, permitting the ready removal of the latter.

As a result of this reforming operation, the bore of the glass tube intimately reproduces the O.D. of the mandrel within a tolerance of ± .003 in. for larger tubes (4 in. to 6 in. diameter) and within ± .0001 in. for fine


Outlet float-stop prevents float from being carried up into pipe line in case of excessive flow.
Stuffing-box retains transparent tube in pipe system.
Maximum flow rate due to maximum annular area is obtained with float up here at large end of tube.
DYNAMIC BALANCE:
Weight of float minus weight of fluid it displaces
Pressure due to fluid velocity
Fluid passes through this annular opening between periphery of float head and I.D. of tapered tube. Of course, flow rate varies directly as area of annular opening varies.
Noting position of edge of float referred to capacity scale on glass gives flow rate reading.
Metering float suspended freely in fluid being metered.
Tapered transparent metering tube (usually borosilicate glass).
Minimum annular area and minimum flow rate (practically zero) is obtained with float down here in the cylindrical bottom piece of the tapered metering tube.
Inlet float-stop prevents float from dropping out of bottom when there is no flow.

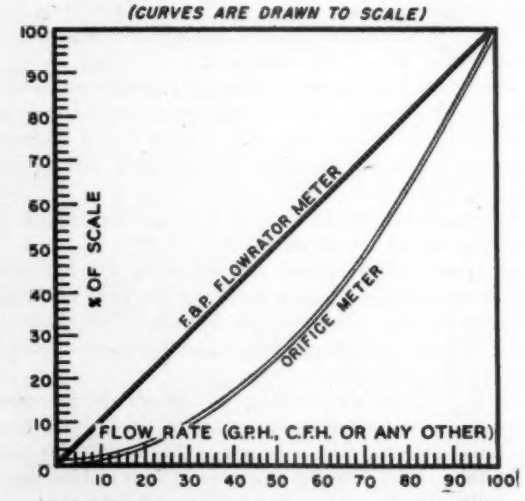


Fig. 2. Schematic of Flowrator and equation of flow; flow rate graph.

Presented before the 58th Annual Meeting of the American Ceramic Society, Glass Division paper # 13, New York City, 25 April, 1956.

capillary tubes. These tolerances are standard for production runs and have been made even tighter for special jobs. The shape of the mandrel is not restricted to straight cylinders. Tapered cylinders, rectangular cylinders and various other forms may also be obtained.

The development of precision reformed glass has been paced by the increasing requirements of industry for higher precision in process control instrumentation and their glass components. Typical has been our own experience, both as manufacurers of process control instruments and fabricators of precision-bore glass tubing.

Thus, in the Fischer & Porter variable area flowrator meter [2], flow is measured by the scale height to which a float rises in a tapered vertical precision bore tube as the fluid streams past the annulus between float and tube (Figs. 1 and 2). The equation of flow is $Q = AC\sqrt{2gh}$, where

Q = Rate of fluid flow
A = Free (annular) opening
C = flow coefficient
g = acceleration of gravity
h = differential pressure due to obstruction

Although this equation also applies to the standard orifice and other variable pressure type meters, the significant thing is that while in the latter Q is proportional to $\sqrt{h}$, in the improved variable area type, Q becomes proportional to A resulting in a linear calibration as illustrated in Fig. 1, and in other functional advantages. However, since A is the small difference between the area of the tube and the area of the float, the condition that the I.D. of the tube had to have its tolerance reduced from its previous value of ± .001 in. to .0002 in. was imposed upon us as glass fabricators, and also met.

Other uses of precision glass components (Figs. 3 and 4) include burets, manometers, capillary tubing, traveling wave tubes, voltage regulator tubes, absorption cells, Raman cells, etc. Their uses cover a multitude of industries—fuels, oils, chemicals, milk, jellies, pulps, slurries, sewage water chlorination, compressed gases, etc. Not only are precision parts found in indicators but also in proportioners and controllers, whether it be to maintain a proper gas-air ratio for optimum combustion in a melting furnace or the complex delicate balance among chlorine gas, chemicals and incoming water in a chlorinator system. In addition to flow and pressure characteristics, other properties like density, viscosity or temperature may be the sensitive means of controlling an operation with the use of appropriate precision glass components.

Precision Starts with the Raw Glass

In fabricating precision glass, the final product will contain most of the defects formed in the raw glass tubing such as airlines, striae, cords, stones, crystals and others. Consequently, the first step consists of rigid inspection of incoming raw glass tubing.

Although a large variety of glass is used, including low expansion borosilicates, soda-limes, soda and potash leads, crowns, phosphates, Vycor, fused silica and experimental compositions, the rigid requirements of precision and strength constrain the bulk of precision glass

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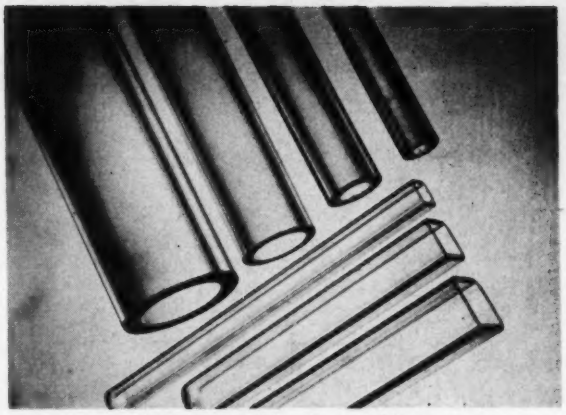

Fig. 3. Precision bore tubing.

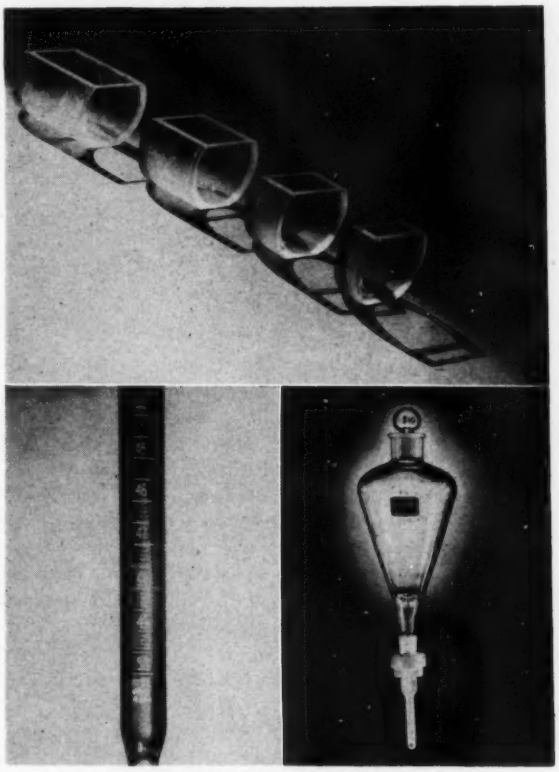

Fig. 4. Precision glass applications.

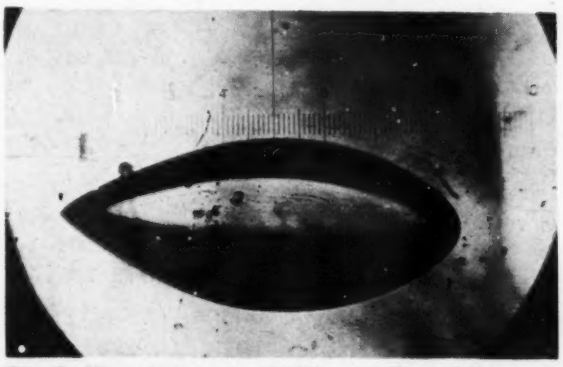

Fig. 5. Microphotograph (X100) of effect of flame on cylindrical air pocket.

Cords In Glass

By M. A. KNIGHT

PART IV

TABLE OF CONTENTS

SECTION II. FACTORY PRACTICE RELATING TO CORDS

IIB. The Batch House

IIB1. Raw Materials
IIB2. Batch Weighing
IIB3. Batch Mixing
IIB4. Batch Transporting

IIC. The Furnace

IIC1. Melting of Batch
IIC2. Attack on Refractories
IIC3. Stagnant Glass
IIC4. Furnace Construction
IIC5. Firing

Conclusion

Acknowledgment

IIB. The Batch House

Gehring (1944) reported that most major fluctuations appearing on the density control chart had their origin in the batch house. He found a correlation of 0.3 to 0.4 between the 3-day range of daily lump density values and the cord rating on the third day. Since cords may arise elsewhere than in the batch house, and since the cord rating used was actually a ware-quality rating, in which the location as well as the intensity of the cord was involved, this partial correlation is to be regarded as significant. Furthermore, three furnaces that were fed from the same batch house showed parallel trends on their density control charts, indicating that all three responded similarly to variations in batch house conditions. The use of control charts on density data is now considered one of the most effective means for evaluating batch-house practice.

We may classify batch-house troubles as (1) non-uniform composition of raw materials, including cullet, (2) inaccurate weighing of batch constituents, (3) inadequate mixing, and (4) segregation of batch during transportation to the furnace. Fortunately, each of these items can be checked readily. Even with inadequate equipment, moreover, much improvement has been realized in many cases through careful control and operation.

The development of good batch houses has been discussed in a number of articles over the years, including Anon. (1935, 1939, 1945a, 1948a), Bardrof (1940), and Lester (1944). Green (1953, 1954) has covered instrumentation in the glass factory.

The complete bibliography covering all four installments of this paper was published in the September issue.

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IIB1. Raw Materials

The raw materials that are used in glass making should be uniform with respect to the proportions of the major chemical constituents, the amount of impurities present, the particle size, and the moisture content. The first three of these should be adequately controlled by the supplier, although his performance in this respect is not always perfect. The moisture content, however, is liable to change during transportation and storage.

Some companies always run complete acceptance tests on each lot of raw material as it is received. Unsatisfactory lots can then be rejected, or they can be segregated during storage. In large scale operations this practice may be worth while, in spite of the extra cost in equipment and labor. Other companies make no tests unless production troubles occur which throw suspicion on the raw materials.

The third and best alternative, adopted by many companies, is to run a limited number of simple tests on each shipment. This involves, naturally, the usual sampling problems; the location, number, and type of samples must be carefully chosen. It is important that any unusual results on these acceptance-tests be carefully confirmed before any changes in batch composition are made.

One of the simplest and most informative acceptance tests is that for particle size. Sieve tests for determining particle size distribution, for example, are easily and quickly made. Any decided change in particle size indicates a possible composition change and also forewarns of a possible change in the mixing and transporting characteristics of the batch, while oversize grains are likely sources of stones and cords. Frolich (1946), studying particle sizes from 0.1 to 0.6mm in soda-lime-silica batches, recommended 0.2mm for all three materials. Poole (1951) obtained a patent based upon unusual sizes for the principal ingredients of container glass batches. He found much more rapid melting (at 10- to 25-fold rates) with his sizes (sand –100 mesh; soda –140 mesh; lime 20/40 mesh) than with all fine or all coarse materials. Kalsing (1952) considered the effects of particle size upon the rate of solution (maximum grain size) and the heat conductivity (grain size distribution). He concluded that rather coarsely graded material could be used provided the gradation was quite uniform and constant. Potts, Brookover and Burch (1944) likewise found advantage in size equality, with the finer sized batches melting more rapidly than the coarser ones. With sizes typical of commercial practice, they found that the role of cullet in melting and segregation was quite variable. Extensive laboratory studies on the rates of melting as functions of the chemical and physical form in which the oxides are used were reported by Abd-El-Moneim Abou-El-Asm (1953), and by Kroger (1952), and Kroger and Ziegler (1953-1955).

Moisture content also is easily determined, but sampling must be especially careful here since the moisture content of a carload lot can vary widely, particularly if rain has leaked into the car. Other simple tests include microscope checks on sand and feldspar for unusual heavy mineral content, and tests for the acid-soluble or hot-water-soluble portions on materials such as soda ash or limestone. Frolich and Hedvall (1944, 1949) recommended the addition of up to 5 per cent of water to aid in the homogenization of the glass during melting. Bozich (1950) patented the addition of 0.25 to 1.5 per cent of -325 mesh pumice to batch materials to prevent caking.

One of the most difficult materials to control is "foreign" cullet. The chances are that this will vary greatly in composition and, further, it may contain metallic contamination from tramp iron, applied color labels, and bottle caps. The effects of variation in composition can be minimized by storing the foreign and plant cullet separately and then mixing some of the plant cullet with the foreign material in the batch. Magnetic separation of the contaminating iron from the crushed cullet should solve the second problem, since applied color labels will not cause trouble under normal firing conditions. Since large pieces of foreign cullet have an adverse effect on glass homogeneity, it is recommended that all lumps of cullet be kept below the 1-inch size. A good review on the use of cullet was given in 1942 (Anon. 1942).

The effects of composition differences betwen successive lots of raw materials can be reduced by blending the last of the old shipment with the first of the new as the material is weighed out. This requires divided bins, or separate bins for each shipment. Although modern storage bins are designed to reduce segregation, caking, and moisture contamination to a minimum, the condition of the material in each bin should be checked periodically.

IIB2. Batch Weighing

Another type of batch house trouble is the inaccurate weighing of the separate batch constituents before they are mixed. The kind of weighing errors, and their frequency, depend upon the type of weighing system and upon the operators' performance. In the most modern type of batch house, the gathering and weighing of the raw materials is automatic. If an error occurs anywhere, safety controls are supposed to stop the process. However, as in any other system, the accuracy of the scales must be checked periodically. In such an automatic installation a minimum number of regular batch men is required. In this connection, see articles by Schwalbe (1937), Motsch (1946), and others (Anon. 1935, 1939). So long as the system works correctly, the only major error in such a system would be that due to having the wrong material in a bin. Motsch discusses features to prevent this occurrence.

Manual systems, in which a batch man weighs and collects the batch, are of two kinds. In one, a single scale is used for all materials, which are weighed successively into a single hopper, or mixer, mounted on a traveling car. This has two disadvantages. First, one scale must be used to weigh both large and small amounts and so does not have the proper sensitivity for all. Secondly, such traveling operation has been reported to be very hard on a scale. The other type uses separate scales for weighing each of the major components, sometimes with devices attached which will record automatically on continuous tapes the actual amounts delivered from each bin. After being weighed, the individual portions are collected for mixing, either by a traveling car or by a belt conveyor. In both systems, the scales must be properly handled, and they should be checked and adjusted at frequent intervals. The scales should have the proper sensitivity, and the operator should receive adequate warning when the amount of material being weighed approaches its specified value. With adequate and correctly adjusted scales, conscientious operators can produce very consistent results. The advisability of a final weighing on the batch has been discussed (Anon. 1945b) as a check on any weighing errors.

An example of a bad weighing error is illustrated by the density-distribution curve shown in Figure 2. The addition of excess soda produced severe tension cords rich in soda, and upset the flow conditions in the furnace. The tension cord shows in the curve as a long, high-density tail. Table X shows chemical analyses of the glass before and two hours after the cord appeared, at which time the packing of ware was stopped. The cord is seen to be poor in silica and rich in soda. Uncertainties inherent in chemical analyses are illustrated here by the inequality of the totals in the analyses. These cords shut down production for 14 hours.

TABLE X

SODA ERROR IN BATCH WEIGHING

	Sample H.P. 1; 10/16/42		
(1) Oxide	(2) Normal Glass	(3) Cordy Glass	(4) Difference
SiO_2	72.08%	70.78%	—1.30
R_2O_3	1.25	1.44	+0.19
Na_2O	16.66	17.61	+0.95
K_2O	0.34	0.39	+0.05
CaO	4.89	4.90	+0.01
MgO	3.43	3.38	—0.05
BaO	1.02	0.87	—0.15
	99.67	99.37	—0.30

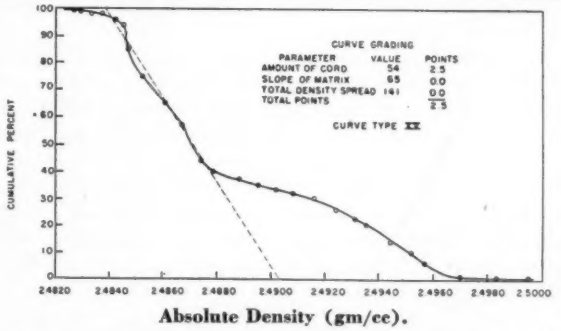


Fig. 2. Density-Distribution Curve 100-200 Mesh Powder Batch Error Cord

IIB3. Batch Mixing

Incomplete mixing of the batch components can lead to general cordiness in the tank, or to segregation and the formation of silica scum in the melting end. Since the effectiveness of the mixing can be easily checked, there should be no difficulty on this score as long as the mixing equipment is adequate.

One method that is used commercially for checking the mix is the acid-solubility test. The acid-insoluble fractions of a number of samples from each of several mixes are determined. These fractions contain the silica and feldspar and any fine cullet not screened out. A spread of 4 per cent or less among six 1-pint samples from a single mix indicates satisfactory mixing; if the spread is more than 6 per cent, the mixing is poor. Additional information as to the limestone and soda ratios can be obtained by running a similar type of test using hot water instead of acid, as was done by Lynn (1932). If there is burnt lime in the batch, however, this test is ruled out because of the hydration of the lime. Brownell and Scholes (1942) used both these methods in a laboratory study of batch mixing.

A more complex method for checking batch uniformity by photometric analysis of x-ray patterns of batch samples was described by Freytag, Hoffman, and Endell (1941). With monochromatic x-rays, fluctuations of less than 2.5% could be detected. This technique is applicable, obviously, only to crystalline materials. Complete chemical analysis could, of course, be used for testing batch uniformity, but it is too slow and too involved for routine control.

Important in any of these testing procedures is the sampling method used. In order to get a true representation of the performance of the mixer, it is recommended that six 1-pint or 1-quart samples be taken from each of several mixes. After the large cullet is screened out with a 10-mesh sieve, each sample should be quartered down to about 40 grams and then the 30-gram sample weighed out for the test. In a plant laboratory test, 24 samples in each of three sample sizes, 100 gram, 1 pint, and 1 quart, were compared with respect to reproducibility of results. No significant difference was found between the pint and quart samples, but both were superior to the 100-gram samples. Hence the sample size should be at least one pint.

IIB4. Batch Transporting

The uniformity of the mixed batch can be checked during its transportation to the furnace by any of the tests discussed in the previous section.

In order to reduce segregation during transportation or during storage in large tanks, there has been a trend toward the use of individual batch cans (each of which holds a single mix) and away from the use of large storage hoppers at the batch chargers. The batch cans may be transported either by truck or by tram-rail system. Schwalbe (1937) discussed the briquetting of mixed batch to prevent segregation during transportation, and also to aid in the charging and melting and to reduce batch dusting in the furnace.

Figure 3 shows the density distribution typical of general cordiness due to batch segregation. In this case, batch from a large standby bin had caused general cordiness when it was introduced into the furnace. Tests of batch uniformity revealed severe segregation in this bin. After a centrifuge density separation was run on samples of this ware, three density fractions were analyzed. The results, given in Table XI, show concentration of silica in the low-density glass and enrichment of the high-density glass by the alkalies and alkaline earths. Polariscopic examination of ring sections from this ware showed general cordiness, with no appreciable amount of uniform "matrix" glass. The highest stress present was a tension of about 2000 psi. The average density values given in Table XI are representative of the respective portions of the density-distribution curve. These show very good agreements with density values calculated from the chemical analysis results by means of density-difference factors. They thus check the reliability of these chemical analyses.

TABLE XI

PARTIAL CHEMICAL ANALYSIS OF SEPARATED FRACTIONS

BATCH CORD

Sample B 1-2; 8/1/42

Columns (2) and (4) show differences from values in column (3)

(1) Description Fraction	(2) Low-Density 92-100%	(3) Intermediate 14-88%	(4) High-Density 0-7%
SiO_2	+0.35%	71.68%	−0.51%
Al_2O_3	−0.08	2.17	+0.02
Na_2O	−0.12	14.08	+0.35
CaO	−0.12	10.72	+0.15
MgO	−0.01	0.32	+0.01
BaO	−0.02	0.83	−0.02
Av. Density	−0.0031 gm/cc	2.5223 gm/cc	+0.0044 gm/cc
Calculated Density Diff.	−0.0032	...	+0.0042

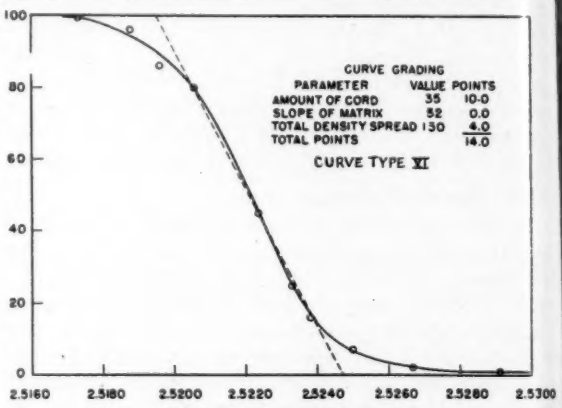


Fig. 3. Density-Distribution Curve 12-oz. Bottle; 100-200 Mesh Powder Batch Cord; General Cordiness

IIC. The Furnace

Assuming that the batch is properly weighed, mixed, and delivered to the furnace, it is still possible for cords to arise in the furnace itself. Such cords may have their origin in the melting of the batch, in attack on the furnace refractories, or in areas of stagnant glass in the tank.

IIC1. Melting of Batch

Charging procedures may, in some cases, compensate for poor performance in the batch house. This was proved in one factory in which two similar, hand-charged furnaces were fed by identical batch houses, and were producing similar ware. The installation of an automatic charger on one of these furnaces led to an improvement in glass quality in that furnace, as compared to its previous performance and to that of the other.

In furnaces which are charged manually, it is not uncommon to find that piles of batch travel too far down in the melting end. Even though the batch is well mixed, such strays may contribute to the formation of cord. Poor charging procedures and poor firing conditions may cause siliceous scum and unmelted batch to spread widely over the melting end, with glasses rich in soda and lime occurring below this surface layer. The result is the formation of both siliceous and soda-lime cords; characteristic glass stones may also be present. Uniform charging of the batch not only minimizes segregation but it also helps maintain a constant glass level in the tank. This last is important, and should be checked regularly. For this purpose there are available automatic devices incorporating electrical contacts at the glass surface (Green 1953) or utilizing photoelectric detection of a beam of light reflected from the surface (Rudinger 1947). Floating refractory blocks may be used to operate mechanical levers, or may serve as targets for sighting mechanisms.

Although, as has been pointed out by Lester (1944), intelligent manual charging by conscientious operators may be highly satisfactory, modern automatic batch chargers have advantages (Bardrof 1940, Lester 1944). They not only maintain a more constant glass level, but they assure a more uniform distribution of batch in the furnace. These are important factors in the prevention of refractory-corrosion cords and batch cords. Two noteworthy developments in automatic chargers are the double feeder mechanism which charges alternately into two sides of a triangular dog house (Anon. 1941a) and the blanket-type feed that extends completely across the dog-house end of the furnace (Lester 1944). With both types, it is possible to adjust the batch distribution with considerable precision, and in both systems dusting is reduced because the batch is glazed by the furnace heat before it enters the furnace proper.

The effects of poor batch charging and melting are illustrated here by two cord cases. Figure 4 shows a typical density distribution arising from segregation in the melting batch caused by improper firing and batch charging; here, the silica-rich, low-density glass remains on the surface of the melt and the heavier fractions, rich in soda and lime, settle toward the bottom. The curve is typical of this trouble. Such curves are characterized by short low-density tails, by high point values for the matrix slope (indicating the virtual absence of homogeneous matrix glass), and by long high-density tails which account for from 5 to 20 per cent of the glass and represent intense tension cords. Thus, this ware was subject to spontaneous crazing on part of the outside surface. Polariscopic examination of ring sections confirmed that this area was under very high tension, indicating enrichment in soda and lime, and, hence, a correspondingly high density. These conclusions were verified by chemical analysis of density fractions separated in the centrifuge, the results of which are shown in Table XII. Once again the calculated and measured density differences agree very well.

As in all this work, the laboratory studies must be correlated with factory observations. In this case, plant studies revealed poor batch charging and unusual furnace temperatures. A bad silica scum was visible on the

TABLE XII

CHEMICAL ANALYSIS OF SEPARATED FRACTIONS MELTING-SEGREGATION CORD

Sample B-R-9; 7/17/42

Column (2) shows differences from values in column (1)

Description Fraction	(1) Matrix Glass 16-93%	(2) High Density Glass 0-8%
SiO_2 (diff.)	72.21%	—0.83%
Al_2O_3	2.12	+0.04
Na_2O	14.05	+0.41
CaO	10.21	+0.37
Others	(1.41)	+0.01
Av. Density	2.5130 gm/cc	+0.0080 gm/cc
	Calculated density difference	+0.0080

TABLE XIII

PARTIAL CHEMICAL ANALYSIS OF SEPARATED FRACTIONS

SILICA SCUM CORD

Sample M-7; 6/2/42

Columns (2) and (4) show differences from values in column (3)

(1) Description Fraction	(2) Low Density 92-100%	(3) Intermediate 6-92%	(4) High Density 0-6%
SiO_2 (diff.)	+1.08%	73.20%	—0.17%
Al_2O_3	—0.13	2.50	+0.00
Na_2O	—0.50	14.80	+0.15
CaO	—0.37	7.50	+0.02
MgO	—0.07	0.90	+0.00
BaO	—0.01	0.10	+0.00
Others		(1.00)	...
Av. Density	—0.0095 gm/cc	2.4755 gm/cc	+0.0013 gm/cc
Calculated Density Diff.	—0.0097	...	+0.0013

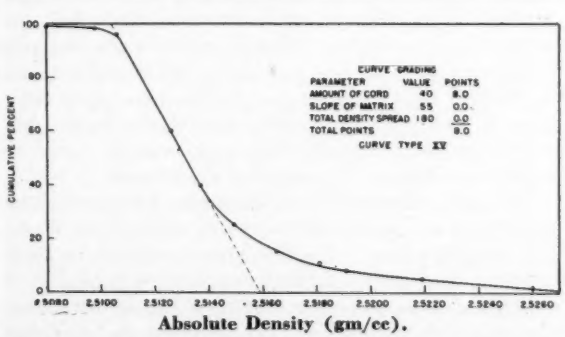


Fig. 4. Density-Distribution Curve 100-200 Mesh Powder Melting Segregation Cord

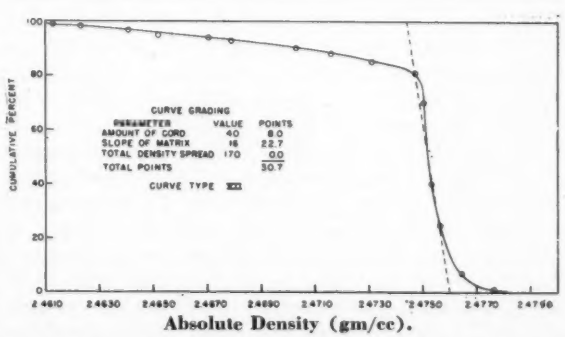


Fig. 5. Density-Distribution Curve 100-200 Mesh Powder Silica Scum Cord

surface of the melt. The high-density glass appeared on the bottom of the feeder channel and localized in the outside surface of the ware as a cord in severe tension. The trouble was eliminated by proper adjustment of the fire in the melting end and by increased care in the charging of the batch.

The second example, Figure 5, is typical of density distributions found on glasses wherein a low-density contamination has been added, without much diffusion, to relatively homogeneous glass. Ring section study showed a localized cord under severe compression. Since there was no boric oxide in this soda-lime-silica glass, there was enrichment in alumina, in silica, or in both. The large density spread on the cord strongly indicated silica enrichment. This was confirmed by the chemical analyses, Table XIII, on the separated density fractions. Here again the calculated density differences indicate that the data are reliable. Although no batch house error in silica was found, there was considerable silica scum in the melting end, and this was the obvious source for the cord.

IIC2. Attack on Refractories

A certain amount of attack by the glass and vapors on the furnace refractories is unavoidable. This attack, however, may be one of the most serious of cords, and it is one of the most difficult to eliminate. Failure of the furnace refractories is the principal limitation upon the rate at which glass can be melted. The higher the temperature, the faster the glass is melted, but the more severe is the attack on the refractories. Furnaces are normally run at the highest temperatures allowable with existing refractories, and as these have improved over the years, melting temperatures have been correspondingly raised. Mooreshead (1944) has called attention to the fact, however, that in some glass furnaces temperatures have been lowered as much as 50° without lowering the over-all efficiency of the melting process.

The quality of the glass pulled from the tank depends upon factors such as the composition of the glass, the temperature and firing conditions in the furnace, the type of refractory, the quality of individual refractory blocks, the rate of removal of the attack products from the attack zone, and the alterations taking place as the melt advances to the forming machines. These conditions differ greatly above, at, and below the glass line, and the severity of attack at the glass line is often of critical importance. Several representative articles on glass attack on refractories are mentioned here. Endell, Fehling, and Kley (1939) studied the effect of viscosity upon the attack rates. Preston and Turnbull (1941) and Loffler (1954) studied the effect on refractory attack of gas bubbles in the melt. Thomas, Kalsing, and Litzow (1942) noted a pronounced decrease in cord trouble with an increased clay content (from 23 to 42.5 per cent) in the refractory. They used both laboratory and tank studies of refractory blocks immersed in the molten glass, using the resulting cords as the criterion for performance. An evaluation of British experience on the performance of tank blocks was made in 1942 (Refractories Committee). Seal (1948) in his studies on alumina-silica refractories concluded that the resistance of refractories was strongly affected by the crystalline and glassy phases present at the glases-refractory interface and by their amounts and crystal development. He concluded also that fine, closely interlocked mullite crystals are desirable.

In interpreting attack on wall blocks, Hampton (1948) obtained calculated curves which show the typical shapes of this attack. By considering the temperature gradients and the effect of glass level fluctuation, he showed that there is no need to assume the presence of any specially corrosive layer at the surface of the melt.

Moore and Heeley (1950) studied glass attack on pure alumino-silicate specimens moved through the molten glass. They concluded that fine grained grog with low proportions of clay, well-fired, was best. They also concluded that actual service tests were necessary to evaluate a refractory. They later studied small additions of sodium silicate in these refractories in an effort to reduce the porosites (Heeley and Moore, 1952). Webber, Siefert and Tooley (1950) developed a laboratory scale test to classify refractories qualitatively, A small tank furnace, producing 6 lb. of glass per hour, was used in simulated service tests on specimens 3 x 7½ x 8 inches. This test gave good prediction of the performance of the refractory in production.

Peyches (1951) patented the use of positive electrodes in the furnace walls and bridge wall, with the negative electrode (water-cooled iron) in the bottom of the glass melt. This system is designed to keep a uniform anionic protective coating on the refractory walls. LeClerc and Peyches (1952) discussed the electrolytic behavior of pairs of dissimilar refractories at different temperatures in glass melts. Thus, an alumino-silicate refractory will be attacked relatively rapidly if used adjacent to a zircon refractory. Application of small potential gradients can prevent this galvanic corrosion.

Discussions on the corrosion of tank blocks in service include articles by Hampton (1948), Gould (1949), and Tress (1954). The use of radiotracers to evaluate attack on tank blocks as discussed by Johnson (1950), Peyches (1954) and Cox and Laing (1954) has already been mentioned. This corrosion depends on the temperature gradients, the absolute temperatures, the fluctuations in the glass level, and the block composition. What happens to the reaction products of the corrosion depends largely upon the compositions of the blocks and the glass and on the temperature and glass flow conditions.

As was discussed in Section I, the refractories of the melting chamber can be classed as silica refractories and alumina refractories, although the latter may contain as little as 30 per cent alumina with the rest being principally silica plus various other components such as zirconia. Cords resulting from attack on these refractories correspondingly can be called siliceous cords and aluminous cords. Highly siliceous cords can arise from silica scum or from attack on silica brick in the crown or shadow wall. Badly eroded throats may allow silica scum to pass into the refining end of the tank. Any stones associated with siliceous cords are very useful in the determination of the source of the trouble.

The most severe attack on aluminous refractories usually occurs on the throat blocks and on the wall blocks near the glass line. The temperature needed to allow sufficient flow of glass through a throat for normal daily production is an indication of the erosion of the throat. The larger the throat becomes, the lower the necessary temperature. In some instances, brick- and steel-work higher in the furnace slag down onto the wall blocks and

erode them badly. The products of attack on aluminous refractories may pass directly into the production glass flow, but often settle to the bottom of the melt. When the cord glass is being drawn from such an accumulated pool of refractory-rich glass, the cord may persist at localized spots in the feeder system until the furnace is shut down, in spite of efforts to change its location. Attempts to drain out the accumulation through holes in the bottom blocks have not proved very successful.

These contamination cords arising from attack on alumina-silica refractories are very troublesome, and as a result they have been studied extensively. They usually have characteristic amber or greenish-amber colors, usually occur as fine streaks, tend to appear at only a few locations in the feeder system, and are very persistent and difficult to eliminate. Although in soda-lime-silica glasses they are undesirable chiefly from the standpoint of appearance, in borosilicates such cords affect mechanical strength as well as color. Two interesting examples occurring in borosilicate ware are reviewed here. In both cases, the cords appeared on the outside surface of the ware and were under severe tension. After the ware had been packed, the cords spontaneously flaked from the surface, or else curled up from it in the form of curved slivers which were up to three inches in length, one-tenth inch in width, and 0.01 to 0.015 inch in thickness. Small but severe tension areas along the centers of the slivers were visible under the microscope. In both instances these peeling cords were found to be rich in aluminous refractory material. After the tanks had been drained there was found, in one case, a large accumulation of the products of refractory attack in the bottom of the tank, and the cord was ascribed to a persistent skimming off of a small amount of this material by the production current. In the other case, the refractory-attack products were found to be draining in a fine stream from a faulty refractory block directly into the production flow.

In another instance, a company submitted samples of borosilicate ware which contained strings and blobs of off-composition glass. These cords were evidently relatively viscous at working temperatures, and some had a greenish-amber color which seemed to indicate aluminous refractory attack. But some of the blobs were colorless. Both kinds contained some crystalline material which was shown by petrographic analysis to be cristobalite devitrification in the colorless blobs and zircon or cristobalite devitrification in the greenish ones. The colorless blobs dissolved readily in molten sodium carbonate; the colored ones did not. Composition differences of the blobs, as compared with the matrix glass, are shown in columns 3 and 4 of Table XIV.

Approximate compositions of two contaminations that could cause these troubles were calculated on the assumption that all the BaO in the glasses was derived from the matrix glass and none from the refractories; these are shown in columns 5 and 6. They agree well with the petrographic evidence. Thus, attack on a silica refractory and on a zirconia-bearing aluminous refractory was indicated. Upon receipt of the laboratory report, the plant operators conceded that the silica shadow wall was severely attacked as a result of running the furnace at excessive temperatures for a time in an attempt to melt the cord, and that, furthermore, there was extensive attack on the zirconia-alumina throat blocks. The severity of the attack on both refractories was greatly decreased by a lowering of the furnace temperatures, although some cords still persisted.

TABLE XIV

INTEPRETATION OF ANALYTICAL DATA ON VISCOUS BLOBS

(All values are in weight per cent.)

(1)	(2)	(3)	(4)	(5)	(6)
		Blob		Calculated	
	Matrix	Composition	Differences	Contamination	
Oxides	Glass	Colorless-Matrix	Green-Matrix	Colorless	Green
SiO_2	74.44	+0.86	−0.46	84.2	70.3
Fe_2O_3	0.052	+0.016	+0.052	0.2	0.6
Al_2O_3	5.44	+0.01	+0.88	5.5	14.2
TiO_2	0.022	+0.011	+0.028	0.1	0.3
CaO	1.06	−0.02	−0.11	0.8	0.0
BaO	2.25	−0.20	−0.23	0	0
MgO	0.06	+0.32	−0.02	3.6	0.0
Na_2O	5.88	−0.17	−0.05	3.9	5.4
K_2O	1.39	−0.13	−0.12	0.0	0.2
B_2O_3	9.12	−0.69	−0.38	1.4	5.4
SO_3	Trace	+0.02	+0.02	0.3	0.2
ZrO_2	None	Trace	+0.35	Trace	3.4
	99.71			100.0	100.0

IIC3. Stagnant Glass

Two types of stagnant glass have been mentioned, namely, silica scum on the surface in the melting chamber, and accumulations, in various parts of the melt, of products of aluminous refractory attack, often enriched by metal scrap. A third type consists of masses of glass of comparatively normal composition which lie outside of the consumption current. Stagnant glass may thus range in composition from this nearly normal glass to glass which is highly enriched in dissolved refractory. Such stagnant areas are more or less normal. Their importance as sources of cord depends upon three factors: (a) the ratio of the total amount of glass in the furnace to the amount in the production flow, (b) the difference in composition between the stagnant glass and that in normal production, and (c) the amount of stagnant glass that is drawn into the production current.

As was mentioned in section *IN*, glass furnaces can vary widely in regard to factor (a). In some, the entire melt moves slowly forward, so that the ratio is nearly unity. In others, the glass from recently charged batch moves rapidly through the tank in restricted channels, and the ratio is much higher. Container-glass tanks appear to be of the latter type, as might be expected from their throat-type construction. The production current flows between masses of comparatively stagnant glass and may drag a little of it along. The opinion has been expressed that when a dense glass is being melted, it will sweep out the refractory attack products about as fast as they are formed, whereas a low-density glass will allow them to accumulate rather rapidly. The many forces involved, however, must each have some effect.

A large composition difference between the stagnant and the production glass, factor (b), leads to cordiness because it cannot be eliminated without extensive mixing. If the difference is small, the glasses either will mix readily or the cordiness will be slight, depending on the

kind of contamination. The amount of the composition difference depends upon the efficiency of the batch mixing and batch melting processes, upon the amount of refractory contamination in the stagnant glass, and upon the number of deliberate batch changes that have been made during the campaign.

The third factor is the amount of stagnant glass that is drawn into the consumption current. Changes in batch composition, the pull on the tank, the glass level, or the firing conditions are likely to cause substantial changes in the flow pattern, and so give rise to cords. Under a steady regime such contamination is small, but if colored streaks or high-tension cords are involved it may be so persistent as to become a major production problem. It has been reported that troublesome cords may arise from batch errors that produce relatively low-density glass but not from those that produce high-density glass. The explanation lies in the difference in the flow behavior of the off-density glasses as they pass through the furnace. The low-density glass moves directly through the furnace along with the normal glass and appears on the top of the feeder channel, with the heavier matrix glass layer on the bottom. On the other hand, high-density glass does not pass through the furnace so readily, but mixes more thoroughly with the normal glass. This leads to a gradual increase in glass density without severe cordiness.

IIC4. Furnace Construction

Developments in the design of glass melting furnaces have been discussed by Longnecker (1943), Mooreshead (1944), Schwalbe (1944), Peyches (1946), and reviewed in the HANDBOOK OF GLASS MANUFACTURE (Schwalbe, 1953). Mooreshead (1954) reviewed the performance of a furnace of a design new in many major aspects. Very satisfactory service had been obtained. Radical changes in furnace design have been proposed by Howard (1948, 1949) and Tangberg (1950).

The development and evaluation of refractories for glass furnaces was discussed extensively in 1949 in a "Glass-Refractories Symposium" by Blau and Smith; Bague; McMullen and Thompson; Knauft; Webber, Siefert and Tooley; Currier; Fabianic; and Meloy and Lambie (1950). Fabianic (1953a) reviewed and tabulated the properties of glasshouse refractories, and discussed their use and service. Parts of reviews by Chesters (1950), and by Dodd (1949, 1953) are pertinent to glass production. Recent short discussions include those by Brown and Stach (1951), White (1954), Johnson (1954), Hicks (1955), Siefert and McEvoy (1955), and Thomas and Knauft (1956). The application of automatic controls to glass furnaces has been reviewed by Rudinger (1947), Early and Hasselbach (1945), Green (1953, 1954), and The Society of Glass Technology (Hill, 1955) which surveyed British practice.

Extensive work on the evaluation of the thermal performance of glass (and steel) furnaces has been carried out in Britain over the past fifteen years or more. This work falls into two categories: (1) thermal efficiency, and (2) the study of flames. The first category, on the development of the Thermal Performance Formula, includes work by Seddon et al (1944), Moxon et al (1944), Dudding (1946a, b), Sismey (1946), and Gould (1946, 1952). Sharp and Ginther (1954) adapted this formula for American usage. They urge wider use of this approach, since useful short cuts are possible in obtaining evaluation of thermal performance from daily operating data.

The British study of flames and heat distribution in regenerative furnaces includes studies by Gooding and Thring (1941), Baulk and Thring (1946), Chesters and Thring (1946, 1947), Thring (1948, 1950), and Brondum-Neilsen (1948). Photography of flames has been discussed by Chesters (1948) using movies of open hearth flames, and has been reviewed by Beral (1949). Chesters' group has also made extensive use of scale models (Chesters and Philip, Howes and Philip, and Halliday and Philip, 1949).

Even the best refractories, used under well-controlled conditions, are subject to some erosion from glass and flame. This may or may not cause cord trouble. It may happen that an individual refractory block is defective, when all the others of the same kind give satisfactory service. At the end of each campaign, the condition of each furnace should be checked carefully and detailed records kept of the performance of the refractories. Schneekloth and Spielvogel (1936), Horak (1945), and Peyches (1947) all have discussed post mortem examination of glass tanks. The greatest amount of information is obtained from a shut-down tank if the glass is frozen at its normal level. The condition of glass and refractories can then be studied in detail as the glass is quarried from the tank. In many cases, this is the only way in which the source of refractory-cord trouble can be determined.

IIC5. Firing

The first step in the control of cords from attack on refractories is careful firing during the initial heating of the tank. A particularly complete article by Arrandale (1945) was reviewed by Schwalbe (1953). The tank should be heated in a such a way that the expansions of its various parts can be controlled and synchronized. The next step is the proper melting of the first glass to be fed into the tank. The first cullet used should be similar in composition to the glass which is to be produced, and it should be so distributed in the tank that no cold masses remain when the furnace is hot. Any stagnant glass near the refractories will then be similar to the rest of the glass, except for refractory enrichment.

The principal firing problems during the campaign are the proper adjustment of the fire to the load on the tank, temperature control in the furnace and checkers, maintenance of a positive pressure in the furnace, prevention of flame impingement upon refractories, and control of the oxidizing or reducing nature of the flame. All of these are directly related to cord prevention. The amount of fire should be decreased when the pull on the tank decreases. Temperature control involves the determination of the most appropriate temperatures, and then the attainment and the maintenance of them. Although temperature readings in all parts of the furnace are important, the regions of maximum temperature must be watched most carefully. The prevention of direct impingement of flame upon the refractories is a matter

(*Continued on page* 690)

Optical Society Meeting

(From A Glass Perspective)

Summary

• The Forty-First Annual Meeting of the Optical Society of America was held at Lake Placid, New York, October 18, 19 and 20. Invited papers dealt with preparation for the International Geophysical Year, new light sources, infrared spectroscopy, new optical materials and fiber optics. The latter two topics included the consideration of new ways of preparing and using glass. Contributed papers were also given in these fields as well as on color, thin films and physiological optics.

New Optical Materials

New optical materials are now required in the infrared range above that of transmission of conventional glasses. There is no question that crystalline materials offer the widest selection and, in the future, the use of crystal growing and ceramic, rather than glass making techniques, for the production of infrared optics is expected to increase. While a range with transmission up to 50 microns appears available, temperature, strength, size, availability and cost limitations restrict their selection and for compromise solutions special glasses were described.

Arsenic Trisulfide Glass

This glass has now been carefully measured by W. S. Rodney, I. H. Malitson, National Bureau of Standards and T. A. Kine, Bureau of Ships, and indices as well as dispersion coefficients, reduced to 25°C. and smoothened mathematically, are available up to 12 microns. The main limitation of this glass is its low softening point. The preparation is by chemical rather than glass making methods.

Oxide Glasses

The properties of some special oxide glasses were measured, and described in illustrated discussion remarks by H. Hafner, R. Weidel and N. Kreidl, Bausch & Lomb Optical Co.

Titanate and Lead Silicate Glasses

These glasses have only fair transmission up to 5 microns, however, when lenses only a few millimeters thick are required, the ease of conventional production, shaping and finishing operations has suggested their use. Indices, dispersion and transmission data are available for three glasses, formulated by G. W. Cleek and coworkers at the National Bureau of Standards.

Calcium Aluminate Glasses

Glasses of this composition have good transmissions up to somewhat above 5 microns. Varieties containing alkali and iron, with little or no silica were formulated by R. Weidel and co-workers, at Bausch & Lomb Optical Co., and measurements are available of optical, thermal and mechanical properties. These glasses are difficult to make, subject to size limitations, react under some artificial weathering tests, but have high strength and thermal stability.

Vitron Theory of Glass Structure

The discussion of new optical glasses culminated in the presentation, by Leroy W. Tilton, of the National Bureau of Standards, of a new theory of the structure of silicate glasses. The word structure, and not constitution, was purposely selected to stress his definite (and radical) concept of stressed imperfectly united "vitrons", 10-30A in diameter, with a regular network of 9A dodecahedral cells having planar pentagonal ring interfaces made up of distorted silicon tetrahedra.

The theory provides adherents of the random and crystalline theory with a common talking ground and/or a common controversy.

Other Optical Materials

The availability of other optical materials, their optical and physical properties and the theory of their absorptive character were, in a series, preceding the discussion of glasses, presented in an extremely interesting fashion by S. S. Ballard, University of California, Miss K. A. McCarthy, Tufts University and A. Smakula, Massachusetts Institute of Technology.

The New Field of Fiber Optics

The development of techniques and applications of transparent fibers has more recently evolved into a growing branch of optics. It not only offers many fascinating possibilities, but also requires the investigation of certain new techniques and principles. Until recently the uses of transparent dielectric cylinders, was limited only to light conductors, commonly called "light pipes." It was not until the year 1952 that work in this field was initiated by Dr. N. S. Kapony at the Imperial College of Science and Technology, London, England, now at the Optics Institute of the University of Rochester, Rochester, New York. Use is made of a bundle of transparent glass fibers to convey light and images along flexible axes. In the new image conveyer a number of regularly packed glass fibers are used, each of which convey light from one element of an image formed on it to the other end of the bundle. This principle is termed as "static scanning".

Their main application lies in an instrument for the endoscopic examination of the internal portion of the human body, for instance, of the stomach by a gastroscope. In this instrument a well aligned bundle of optical quality borosilicate crown glass fibers (25μ or 50μ diameter) is used to convey light and image from places inaccessible to direct observation. In such diagnostic

(*Continued on page* 694)

Inventions and Inventors

Annealing and Tempering

Glassware Take-Out Mechanism. Patent No. 2,748,920. Filed Oct. 10, 1952. Issued June 5, 1956. Seven sheets drawings; none reproduced. William R. Morgan.

The present invention relates to glassware take-out mechanisms that are used for withdrawing glassware, and particularly glass container ware, such as bottles, from a glass molding machine, and transferring it to some other point, such as to a conveyor by means of which it may be moved to a lehr for further treatment.

An important object of the invention is to provide a glassware take-out mechanism having a rotating carriage which incorporates a hydraulic brake adapted to prevent the carriage from rotating under the influence of lateral cam forces.

There were 17 claims and the following references were cited in this patent: 2,609,943, Winder, Sept. 9, 1952 and 661,573, Great Britain, Nov. 21, 1951.

Decorating Glassware. Patent No. 2,746,193. Filed August 18, 1954. Issued May 22, 1956. One page drawings; none reproduced. Assigned Owens-Illinois Glass Co. by Carroll J. Billian.

This invention relates to methods and means for utilizing high energy radiation for coloring and decorating glassware and for other purposes. When certain types of glass are subjected to high energy radiation such as cathode rays or bombarded with high velocity electrons, the clear glass turns into an amber or brown color.

In accordance with the present invention this phenomenon is utilized for decorating glassware. An article such as a glass jar, for example, is decorated with a color design by cutting or stenciling the design in a mask, such as a sheet of lead, which is placed over the surface to be decorated and is then subjected to the radiation. The portion of the glass outlined by the stenciled design is thus exposed to the radiation and assumes a characteristic amber or brown color. This provides a method for quickly decorating, printing or applying such a design to the glassware without requiring any further treatment. Operations, such as heating, drying, baking or curing, required in usual methods of decorating or printing on such glassware, are eliminated.

The high energy radiation may also be employed for sterilizing a glass container and its contents when packed with a food product or other material. The entire package is subjected to the radiation which penetrates the glass, sterilizes the contents of the container and gives to the glass a characteristic color which serves the purpose of indicating that the product has been sterilized in this manner.

The amount of color produced varies to some degree with the base composition of the glass, but the presence or absence of any given major oxide used in commercial glass practice does not prevent coloration.

Ceric oxide can be used for minimizing and effectively preventing coloration in flint glass. Ceric oxide contents of about 1 per cent effectively prevent coloration in soda-lime-silica and borosilicate commercial compositions, although the amounts necessary are slightly different for these two glasses. There were 8 claims and the following references were cited in this patent: 2,628,160, Stookey, Feb. 10, 1953 and Summer, November 1952 issue of *Manufacturing Chemist*, pages 451-455.

Feeding and Forming

Steel Glass Seals. Patent No. 2,745,739. Filed October 22, 1952. Issued May 15, 1956. No drawings. Assigned to United States Steel Corporation by Freeman J. Phillips and Charles O. Tarr.

It is an object of the present invention to provide chromium stainless steels suitable for forming by spinning and for sealing to glass containing less chromium than steels heretofore usable.

It has been discovered that chromium steels within the range of 9.5 to 12.5 per cent chromium containing less than .10 per cent carbon are generally suitable if they contain at least .50 per cent titanium, along with .25 to about 1.00 per cent molybdenum, aluminum within the range of .02 to .30 per cent, silicon .10 to 1.00 per cent, manganese .10 to .75 per cent and less than .50 per cent nickel. While the upper limit of titanium is not critical with respect to the purposes of the invention, it is generally maintained below about 1 per cent, since larger amounts cause objectionable stringers. Phosphorus and sulphur should be maintained as low as possible. Small quantities of boron, vanadium and tungsten are not desirable, but may be tolerated. The balance of the alloy is substantially iron.

The following table lists the analyses of a number of steels embodying the inventions:

	C	Mn	P	S	Si	Ni	Cr	Ti	Mo	Al
A	.060	.54	.011	.015	.26	.33	9.85	.66	.53	.16
B	.058	.59	.012	.017	.34	.34	13.30	.58	.53	.15
C	.064	.55	.008	.010	.19	.39	10.85	.55	.90	.11
D	.028	.64	.009	.012	.16	.39	10.72	.54	.84	.12

There were six claims and the following references were cited in this patent: 1,947,417, Holst, Feb. 13, 1934; 2,024,561, Becket, Dec. 17, 1935; 2,670,572, Smith, Mar. 2, 1954; 730,161, Germany, Jan. 7, 1943 and *Metal Progress*, vol. 52, July to December publications, pages 94 to 96, and 102. Published by the American Society for Metals, Cleveland, Ohio.

Method of Feeding Glass Batch Materials. Patent No. 2,749,666. Filed March 24, 1952. Issued June 12, 1956. One page drawing; none reproduced. Assigned to Cohart Refractories Company, by Harold W. Baque.

A glass-melting tank is provided, at its glass batch-receiving end with a doghouse, separated therefrom by the end wall of the tank, but in communication therewith by way of a submerged throat or passage through such end wall. Mechanism is provided to push charges of glass batch materials, accumulated on the molten glass surface within the doghouse, down into the molten glass occupying the outer end of the passage between the doghouse and the glass-melting tank, where the batch

materials are prevented from immediately rising to the surface by the section of the tank end wall defining the upper limit of such passage. The batch charges are thus positively held below the surface of the molten glass and are progressively advanced by the introduction of succeeding batch charges, until they finally emerge at the inner end of the passage and only then rise to the surface and become exposed to the action of the flames within the tank. As will be appreciated, during the period of their progressive advancement, the charges of batch materials are surrounded by hot molten glass which thoroughly coats and impregnates them before they are permitted to rise to the molten glass surface, by which time substantially no volatilizable or finely divided batch materials remain available for exposure to the flames.

There was one claim and the following references cited in this claim. 776,196, Nicholls, Nov. 29, 1904; 1,761,229, Pederson, June 3, 1930; 1,905,534, Wadman, Apr. 25, 1933; 1,999,761, Howard, Apr. 30, 1935; 2,397,852, Gentil, Apr. 2, 1946; 2,479,805, Batchell, Aug. 23, 1949 and 2,471,336, Lorenz, May 24, 1949.

Glass Feeder Vertically Reciprocable Implement. Patent No. 2,749,665. Filed December 24, 1951. Issued June 12, 1956. Two pages drawings; none reproduced. Assigned to Emhart Manufacturing Co., by Karl E. Peiler.

This application is a division of a co-pending application for Letters Patent for improvements in glass feeding apparatus, filed April 21, 1949, Serial No. 88,869, on which U. S. Patent No. 2,654,184 was issued October 6, 1953. A novel means is disclosed for supporting and operating a vertically reciprocable implement, sometimes termed a "plunger", in relation to a glass discharge outlet in the bottom of a container for molten glass into which the implement depends.

An improved cam-actuated and controlled mechanism is provided for supporting and reciprocating the vertical implement of the feeder, relative to the glass discharge outlet in the bottom of the feeder container, to assure steady strokes of the implement under all operations.

Means are also supplied to subject the implement to a constant downward force of substantial amount beyond that caused by the weight of the implement and its supporting means. This will prevent the bouncing of the cam follower of the mechanism on the periphery of its cam, when the implement is being reciprocated at high frequency; also it aids downward strokes of the implement when it is of relatively large diameter and is being reciprocated slowly in glass that is relatively cold and viscous, as in the feeding of heavy-weight charges.

There were 2 claims and 11 references cited.

Mold Closing Mechanism. Patent No. 2,748,536. Filed September 24, 1954. Issued June 5, 1956. Two pages drawings; none reproduced. Assigned to Owens-Illinois Glass Company by Russell G. Allen.

This invention relates to glass molding mechanism of the type in which the mold halves of split molds are mounted to swing to and from the mold closing position.

A mold closing mechanism is provided which will give high closing pressure and provides a compact mold closing mechanism, which is cam operated, and which employs a short cam stroke combined with ample over travel of the cam as a safety means when normal closing of the mold is prevented.

There were 8 claims and the following references were cited in this patent: 1,431,436, Winder, Oct. 10, 1922; 1,529,661, Miller, Mar. 17, 1925; 2,367,799, Robinson, Jan. 23, 1945 and 2,466,669, Winder, Apr. 12, 1949.

Surface Coating Glassware. Patent No. 2,747,541. Filed June 21, 1954. Issued May 29, 1956. Two pages drawings; none reproduced. Assigned Owens-Illinois Glass Company by Clarence Chew.

The present invention is a novel method and apparatus for applying to the rim, or beaded edge portion, of glass tumblers and the like, a coating of wax which serves to protect these surfaces against scratching or chipping, while being subjected to the conventional handling which follows the annealing operation.

The wax solution which is "polyethylene 100 monostearate", is sprayed upon the surface of the applicator roll by means of a series of spray heads, of which there may be three or more, uniformly spaced across the width of the lehr and each suitably connected to a mixing chamber, which in turn is connected to air and wax solution supply pipes. These units are suspended from a carrier bar which is part of a frame and may be adjustably mounted in upright supports. These upright supports, in turn, are mounted upon a pair of carrier arms which extend horizontally from and are vertically adjustable upon brackets.

In order to control the application of the wax solution to the applicator roll and prevent wind, currents, etc., from deflecting the sprayed solution, a hood is secured to the lower side of the carrier arms, such hood tapering downwardly and opening at a point in close proximity to the peripheral surface of the applicator roll.

As the tumblers move out of the exit end of the annealing tunnel or oven and while still comparatively warm from the annealing operation, being approximately 125°F., they pass beneath and in contact with the chamois skin faced wax solution carrying periphery of the applicator roll. This applicator roll is sufficiently soft to permit a very slight projection of the rim or bead portions of the glassware, so that the wax application coats not only the upwardly facing surfaces of the rim or bead, but additionally, at least a part of the exterior side surfaces provide a protective coating in the areas of frequent contact between tumblers or similar articles. These tumblers after the coating operation, proceed toward the discharge end of the lehr and incident to cooling to room temperature, the wax firmly sets and becomes a more or less permanent part of the article. In any event the permanence is sufficient to protect the rim or bead areas during normal and to a large extent, abnormal rough handling.

There were 4 claims and the following references were cited in this patent: 1,945,086, Schmitt, Jan. 30, 1934; 2,004,079, McManus, June 4, 1935; 2,132,138, Williams et al., Oct. 4, 1938 and 2,522,121, Keller, Sept. 12, 1950.

Glass Compositions

Optical Glass. Patent No. 2,748,006. Filed December 6, 1952. Issued May 29, 1956. No drawings. Assigned to Bausch & Lomb Optical Company by Norbert J. Kreidl and Earl K. Davis.

This invention relates to glass compositions and more particularly it has reference to optical glasses which are adapted to be used for the manufacture of lenses for sun glasses or the like which reduce the intensity of light rays reaching the eye.

The ideal sun glass lens has neutral light absorbing properties so that it will function to reduce the intensity of light rays, while still permitting colored objects to be viewed through the lens without change in color values. A refractive index of about 1.523 is desirable.

The following are examples of glasses calculated from their respective batches and embodying the invention:

	Example		
	1	2	3
SiO_2	54	61	57
B_2O_3	18	4	11
Al_2O_3	1.5	14	10
K_2O	13.0	5.0	5.5
Na_2O	....	4.5	7
Li_2O	....	5.5	3.5
KHF_2	1.5	1	....
ZnO	3.5	2	.86
ZrO_2	5.0	....	....
Fe_2O_3	2.7	2.9	3
Co_3O_4	.006	.006	.006
As_2O_5	.5	....	....
Si	.294	....	....
C	....	.094	.134
P_2O_5	....	....	2
	100.000	100.000	100.000
N_D	1.514	1.524	1.523

There was one claim and the following references were cited in this patent: 1,143,732, Schott, June 22, 1915; 2,582,852, Shoemaker, Jan. 15, 1952 and 356,322, France, 1905.

Glass Having Interface Reduced Lead, Diffused Silver. Patent No. 2,748,020. Filed October 27, 1950. Issued May 29, 1956. One page drawings; none reproduced. Assigned Eastman Kodak Co. by William F. Parsons and Juanita N. Little.

This invention relates to non-reflecting coatings on glass, and more particularly to black coatings of reduced lead on glass, which are non-reflecting at the internal interface and to methods for their production.

It has been found that the presence of silver in a lead glass causes the lead to be reduced at a lower temperature than that in a glass containing no silver. For instance, when a silver stained glass and a plain lead glass are reduced simultaneously in hydrogen for one hour at 700°F., the glass containing silver is found to be substantially more opaque. A longer reducing time does not produce the desired coating without the presence of silver. Since the depth of the diffused silver is somewhat critical and since silver was found to assist reduction, we base the phenomena of decreased reflection on the premise that a graded interface of reduced lead is formed at the glass surface. That is, that the concentration of lead atoms gradually decreased from the glass-air interface to the internal interface of the coating.

It will be apparent from the foregoing description that the necessary theoretical requirements for high absorption are fulfilled by these coatings.

The invention with lead glass can be carried out by employing the following steps: (1) Chemically silver, evaporate, or otherwise deposit silver on the glass surface to be coated. That is, any suitable silvering method known to the art can be employed. (2) Heat the glass in an oven in an oxygen atmosphere at a temperature which will cause the silver to diffuse into the glass surface not yet coalesced. It is desirable when coating small pieces to place them in the oven on a polished lava block. The block and the glass can then be removed from the oven while hot, thereby lessening the chance of cracking the glass. (3) Reduce the silver stained glass in an atmosphere of hydrogen for one hour at 850°F. The above-described coatings are most satisfactorily employed on glass optics when they are applied before the optical surfaces are polished.

Since it is also desirable to produce absorbing coatings on glasses which do not contain lead, it is also a feature of them to provide a suitable method to do that.

It has been found that under the proper conditions, lead deposited either as the metal or as a salt, can be fluxed into a glass surface at a temperature below the softening point of the glass. When the proper concentration of lead is employed for the type glass being coated, this layer of lead glass is quite stable, transparent, and free from cracks and bubbles. Conditions as to the amount of lead, temperature and length of time of fluxing vary with the glass being coated.

Lead borate, lead acetate, powdered lead glass, evaporated lead, and chemically deposited lead sulfide are all suitable as fluxing materials. We found that a simple, inexpensive way to produce this layer of lead glass on lead-free glass is to deposit an even coating of 300 mesh lead powder and then heat the glass at a temperature just below its softening point. 200 mesh powder may be used, but the smoothest surfaces are obtained with the finest powders.

In order to hold the lead powder firmly to the glass article, the surface to be coated is covered with a thin film of light grease. A dilute solution of grease in benzene is applied by brushing, spraying, or other means, and this deposit is smoothed to a continuous film.

If properly applied, these coatings are as stable as those produced on a base lead glass and will withstand temperature extremes of 600°F. to —85°F. and are as resistant to chemical action and abrasion as any lead glass.

There were 3 claims and the following references were cited in this patent: 1,181,754, Ferriter, May 2, 1916; 2,315,328, Hood et al., Mar. 30, 1943; 2,456,241, Axler et al., Dec. 14, 1948; 2,501,563, Colbert et al, Mar. 21, 1950 and 2,597,562, Blodgett, May 20, 1952.

Sheet and Plate Glass

Anti-Reflecting Coating for Color Filters. Patent No. 2,741,157. Filed December 5, 1952. Issued April 10, 1956. Three pages of drawings; none reproduced. Assigned to Franke & Heldecke, Fabrik Photographischer Prazisions-Apparate by Rudolf Goethert.

The present invention relates to anti-reflective coatings on color filters for photographic purposes.

Improved results are attained by applying to the glass two coatings, first an undercoating of tantalum oxide, and over it a second coating of magnesium fluoride, both coatings being applied in a vacuum by the known processes of vaporization or cathode sputtering. The thicknesses vary according to the wave length which corresponds approximately to the center of the range of the visible or photographically active light which is to be transmitted by the color filter in question. The first or tantalum oxide coating should have a thickness of 5/64 of the wave length in question divided by the index of refraction of tantalum oxide. The second or magnesium fluoride coating should have a thickness of approximately 5/16 of the wave length in question divided by the index of refraction of magnesium fluoride.

Expressing these relationships by means of a formula, it may be written as

$$d_1 = \frac{5\lambda}{64\ n_1}$$

and

$$d_2 = \frac{5\lambda}{16\ n_2}$$

Where d_1 is the thickness of the first or tantalum oxide coating and n_1 is the index of refraction thereof, d_2 is the thickness of the second or magnesium fluoride coating and n_2 is the index of refraction thereof, and λ is the wave-length which corresponds to approximately the center of the range of the visible or photographically active spectral range intended to be transmitted by the color filter in question. This range may hereafter be referred to for convenience as the "desired range" or "desired spectral range" of the light.

The externally visible color of coatings applied according to the present invention, is somewhat different from filters coated according to the prior art. For example, when a blue filter is treated according to the present invention the coating gives the appearance of yellow-brown. A green filter treated according to the present invention has a coating which appears to be of a violet color. A red filter according to the present invention has a coating which has a blue-green appearance.

There were 2 claims and the following references were cited in this patent: 2,281,474, Cartwright et al., Apr. 28, 1942; 2,360,403, Dimmick, Oct. 17, 1944; 2,366,516, Geffcken et al., Jan. 2, 1945; 2,366,687, Osterberg, Jan. 2, 1945; 2,403,685, Sachtleben et al., July 9, 1946 and King et al.: "Experimental and Theoretical Results in Two-Layer Low Reflecting Coatings for Glass," article in the *Journal of the Optical Society of America*, vol. 36, No. 9, September 1946, pages 513-517 inclusive.

Bending Glass Sheets or Plates. Patent No. 2,744,359. Filed March 27, 1951. Issued May 8, 1956. Two sheets drawings; none reproduced. Assigned Libbey-Owens-Ford Glass Company by Joseph E. Jendrisak.

The present invention relates to an improved method and apparatus for the bending of glass sheets or plates or other sheet material to predetermined curvatures. The improved method is carried out by the use of novel apparatus. This comprises a bending mold having a shaping surface of the desired curvature and preferably of the continuous ring type, with which is associated means for supporting the glass sheet to be bent in an inclined position above the mold and, for effecting a gradual lowering of the sheet during the bending until it is deposited upon the shaping surface of the mold.

The mold is further provided with means for supporting the upper end of the sheet. It comprises a pivoted support which serves to maintain the body of the sheet out of contact with the mold during the initial bending of the sheet. The support operates to automatically swing downwardly as the sheet is progressively bent and to bring the sheet to rest upon the shaping surface of the mold at substantially the completion of the bending operation whereby sliding contact of the sheet with the mold will be avoided. This procedure thereby minimizes and eliminates mold marks and other defects in the softened glass.

There were 15 claims and the following references were cited in this patent: 682,570, Sage, Sept. 10, 1901; 2,348,278, Boyles et al., May 9, 1944; 2,518,951, Smith, Aug. 15, 1950 and 2,608,799, Babcock, Sept. 2, 1952.

Treating Sheet Glass. Patent No. 2,736,140. Filed July 27, 1951. Issued February 28, 1956. Four pages drawings; none reproduced. Assigned Pittsburgh Plate Glass Company by L. V. Black.

This invention relates to apparatus for bending sheet glass. Skeleton molds are so designed that each mold unit is included in a frame structure adapted to travel along a horizontal roll conveyor.

Each mold frame with a sheet glass unit mounted thereon is transported into a furnace which is heated to proper temperature incidental to the softening of the glass, for example, to approximately 1050°F. The furnace is equipped with facilities to apply localized heat at higher temperatures. Electric heating elements can be employed for this purpose to direct heat by radiation and in concentrated form to localized areas adjacent the end portions of the sheet glass unit, where the sharper bending is to be effected. The concentrated and localized heat is applied at such value to rapidly increase the temperature in selected areas of the glass unit from approximately 1050°F. to 1200°F. The glass is then immediately bent to the shape of the mold without producing an appreciable transverse curvature, either at the end portions or at the intermediate portions between the sharply bent portions. The concentrated and localized heat is applied only until the glass unit assumes the proper shape. Forces are applied to end portions of the sheet glass unit as a result of peculiarities in the structure and action of the glass supporting mold frame. These forces cooperate with the conveyor system and with the concentrated localized heat to accomplish optimum bending with proper proportions of heat and applied bending forces. The conveyor is operated upon completion of the bending action to transport the glass to a position between upper and lower groups of air jet producing blowers, so designed to apply the air jets at approximately right angles to tangents to the glass curvature, substantially at the points of impact of the jets against the glass surfaces.

The glass supporting mold is held in proper position between the groups of oscillating jets until the glass becomes case hardened or tempered.

There were 8 claims and 10 references cited.

Research Digest

Petrology of Fused Cast High Alumina Refractories

(*Editor's Note:* The use of fused cast high alumina refractories is increasing rapidly in the glass industry and while the following paper contributes little to actual glass problems it is interesting to know just how the materials of glass furnace construction are "put together".)

Petrology, the comprehensive science that deals with the origin of rocks, interpreting their history and structures with the aid of petrographic and other data has been used to only a limited extent in ceramic technology. Since fused cast crystalline ceramic products originate from molten fusion of oxides, which are analogous to natural magnas, and cool and crystallize under conditions that approach phase rule equilibria, the methods of petrology are particularly adaptable to their study and H. N. Baumann in the September 1956 issue of the *Bulletin of the American Ceramic Society* reports the result of such a study conducted on three types of fused cast refractories, namely, (1) Type H consisting entirely of soda beta alumina, (2) Type MH of alpha alumina and soda beta alumina, and (3) Type K of chrome alumina and a chromium oxide containing magnesia epinel.

Cross sections of large blocks of these three types were examined. On the basis of the data from petrographic, X-ray diffraction and chemical analyses, the paths of crystallization and the mechanics of solidification of one of these are traced, and their relation to the structure of the final product interpreted.

These three types differ not only chemically and crystallographically, but also structurally, as a result of their different ways of solidifying. One of these (designated Type H for reference) consists essentially of a single crystalline phase, practically free of included impurities. There is no natural igneous rock directly comparable in structure and purity to Type H, unless it be ice which petrologists often consider a type of igneous rock whose parent magma is water. While the relationship may appear strained on account of the extreme temperature differences, petrologists have found the behavior of polar and glacial ice helpful in interpreting the history of normal igneous rocks.

Since H is a single phase crystalline material, beta alumina ($11Al_2O_3.Na_2O$), and is completely liquid when it is poured into molds to produce refractory blocks, its solidification is quite simple. Crystallization begins at the mold-liquid interface but there is no marked difference in size of crystals developed near the surface and those finally obtained in the center.

There appears to be another analogy between ice and beta alumina in that it expands on solidifying, a phenomenon that would account for the dense structure and freedom from piping characteristic of H.

A second type, designated MH, is a modification of H and consists crystallographically of 60 per cent beta alumina, 38 per cent alpha alumina, and 2 per cent well dispersed interstitial and included glass. Microscopically, MH ig granitoid on fractured surfaces; petrographically it consists of interlocked anhedral crystals of beta and alpha alumina, the former being much smaller than Type H. The petrology is again quite simple, the granite-like structure is fairly uniform from the surface inward to the center of the block. The absence again of any marked piping is caused by the expanding property of beta alumina on freezing. While there are no phase rule data to help in interpreting the mechanics of solidification, on the basis of our experimental experience, it appears that the composition of MH may be near the binary eutectic between beta and alpha alumina, a condition that would account for the absence of any marked segregation.

Type K, the third variety of high alumina fused cast refractory, differs radically from both types previously described. Its chemical composition is such that its related to two ternary systems whose phase rule diagrams have been published, and a good picture of the nature of solidification and crystallization of K blocks may be developed by analogy. These two known systems are the system $MgO\text{-}Al_2O_3\text{-}SiO_2$ and the system $FeO\text{-}Al_2O_3\text{-}SiO_2$.

The effectiveness of Type K refractory material depends on the experimentally demonstrated fact that the resistance of corundum and spinels to corrosion by many commercial glasses is increased by the introduction of chromium oxide (Cr_2O_3) into solid solution with aluminum oxide and the aluminates. It is probable that the immiscibility of molten chromic oxide and silica is a factor in this resistance to corrosion. The source of chromic oxide is chromite, which is the only natural commercial source of chromium oxide, and the alumina which forms the major portion of the fusion, is derived from electric furnace refined bauxite and chemically contains more than 96 per cent Al_2O_3, the balance being chiefly SiO_2 and TiO_2.

The two crystalline phases of which Type K is composed are chrome-corundum and a spinel approximately the composition of the natural mineral picotite. Quantitative back reflection X-ray diffraction analyses indicate that the aluminum oxide and chromium oxide are essentially always in the same proportion in the chrome-corundum and that there is no concentration of chrome oxide in any part of the block.

Any fused cast crystalline product containing two or more crystalline phases, one of which crystallizes as a primary phase, will have some tendency to segregate, or be non-uniform from the surface of the product into the center. Alpha alumina and spinel, however, crystallize so readily and the rate of cooling is so rapid that this tendency is minimized. The small amount of silica and titania, and the practical absence of alkalies and alkaline earths in Type K has no retarding effect on this rapid crystallization. Fuse cast refractories high in silica and fluxes, however, tend to solidify with considerable glass, even under the best conditions of solidification.

(*Continued on page* 696)

Current Statistical Position of Glass

Employment and Payrolls: Employment in the glass industry during September, 1956 was as follows: *Flat Glass:* A preliminary figure of 30,800 for September indicates an increase of 1.0 per cent from the adjusted 30,500 reported for August, 1956. *Glass and Glassware, Pressed and Blown:* A decrease of 4.5 per cent is shown by the preliminary September figure of 78,000 when compared with 81,700 of August, 1956. *Glass Products Made of Purchased Glass:* The preliminary 15,200 indicates an increase of 2.0 per cent from the previous month's figure of 14,900.

Payrolls in the glass industry during September, 1956 were as follows: *Flat Glass:* An increase of 2.5 per cent is shown in the preliminary $14,901,656 when compared with August's adjusted $14,540,875. *Glass and Glassware, Pressed and Blown:* A decrease of 6.0 per cent is shown in the preliminary $26,218,920 reported for September, when compared with the previous month's adjusted $27,894,014. *Glass Products Made of Purchased Glass:* A preliminary figure of $4,501,328 was reported for September, 1956. This is an increase of 1.8 per cent compared with the adjusted figure of $4,423,512 of the previous month.

GLASS CONTAINER SHIPMENTS

(All Figures in Gross)

Narrow Neck Containers

	Oct. 1956
Food	1,708,000
Medicinal and Health Supplies	1,754,000
Chemical, Household and Industrial	945,000
Toiletries and Cosmetics	956,000
Beverage, Returnable	885,000
Beverage, Non-returnable	108,000
Beer, Returnable	103,000
Beer, Non-returnable	744,000
Liquor	1,350,000
Wine	524,000
Sub-total (Narrow)	9,077,000

Wide Mouth Containers

Food	*4,039,000
Medicinal and Health Supplies	532,000
Chemical, Household and Industrial	212,000
Toiletries and Cosmetics	234,000
Packers' Tumblers	115,000
Dairy Products	306,000
Sub-total (Wide)	5,438,000
Total Domestic	14,515,000
Export Shipments	315,000
TOTAL SHIPMENTS	14,830,000

*This figure includes Fruit Jars and Jelly Glasses.

GLASS CONTAINER PRODUCTION AND INVENTORY

(All Figures in Gross)

		Production Oct., 1956	Stocks Oct., 1956
Food: Medicinal and Health Supplies; Chemical, Household and Industrial; Toiletries and Cosmetics	Narrow Neck	4,787,000	4,216,000
	Wide Mouth	*4,801,000	*3,802,000
Beverage, Returnable		668,000	1,075,000
Beverage, Non-returnable		68,000	159,000
Beer, Returnable		97,000	229,000
Beer, Non-returnable		649,000	474,000
Liquor		1,468,000	983,000
Wine		503,000	430,000
Packers' Tumblers		114,000	131,000
Dairy Products		280,000	242,000
TOTAL		13,435,000	11,741,000

*This figure includes Fruit Jars and Jelly Glasses.

Glass Container Production, based on figures released by the Bureau of Census was 13,435,000 gross during October, 1956. This represents an increase of 34 per cent from the previous month's production of 10,032,000 gross. During October, 1955, glass container production was 12,173,000 gross or 10.3 per cent under the October, 1956 figure. At the end of the first ten months of 1956, glass container manufacturers have produced a total of 120,439,000 gross. This is 4.2 per cent over the 115,538,000 gross produced during the corresponding 1955 period.

Shipments of glass containers during October, 1956 increased 41 per cent to reach 14,830,000 gross. This is an increase from September, 1956 shipments which were 10,520,000 gross. Shipments during October, 1955 were 11,539,000 gross or 28.6 per cent under October, 1956. At the end of the first ten months of 1956, shipments have reached a total of 120,424,000 gross, which is 6.1 per cent over the 113,523,000 gross shipped during the corresponding period last year.

Stocks on hand at the end of October, 1956 were 11,741,000 gross. This is 10.1 per cent below the 13,162,000 gross on hand at the end of September, 1956 and 14.5 per cent lower than the 13,719,000 gross on hand at the end of October, 1955.

Automatic Tumbler Production during September, 1956 was 577,000 dozen. This is a loss of 88 per cent against the August, 1956 production, which was 4,922,000 dozen.

Shipments during September, 1956 dropped to reach 860,000 dozen. This is 84 per cent lower than the 5,524,000 dozen shipped during August, 1956. At the end of the twelve months period ending September, 30, 1956, shipments have reached a total of 56,486,000 dozen which is 8.6 per cent less than the 61,813,000 dozen shipped in the twelve month period ending Sept. 30, 1955.

Table, Kitchen and Household Glassware Manufacturers' sales of machine-made table, kitchen and household glassware during September, 1956 reached 729,000 dozen. At the end of the twelve month period ending September 30, 1956 manufacturers had sold a total of 32,834,000 dozen, which was 13.2 per cent lower than the 37,835,000 dozen sold during the corresponding 1955 period.

New Equipment and Supplies

VACUUM OPERATED MATERIAL HANDLER

International Staple and Machine Company, Materials Handling Division, Herrin, Illinois has developed a new vacuum-lifting device, known as the International Air-Lift.

According to the manufacturer, it is very simple to operate. A vacuum is created as soon as the device is placed on an object, and remains effectively sealed by means of a special Neoprene gasket. To release the object, the operator simply presses a handy release valve with his thumb, the air rushes in, the vacuum is broken and the object is released. It is a portable hand model and capable of lifting up to 200 pounds. For heavier operations, International also manufactures a complete line of pads utilizing the same principle capable of lifting 600, 1000 and 1500 pound capacities. For further information the company should be contacted.

ELECTRONIC POTENTIOMETER RECORDS ON 3-INCH STRIP-CHART

The Bristol Company of Waterbury, Connecticut has just announced a new self-balancing electronic potentiometer which gives a continuous record on a 3-inch strip-chart.

The new Dynamaster recorder, which uses standard components, is housed in a case only 5 inches square, to blend with other modern miniature instruments. It is identical in appearance to the company's Metagraphic Pneumatic Recorder. Accuracy and sensitivity are unchanged from the standard 12-inch instrument.

The small-size self-balancing instruments are also furnished in indicating models. The indicating and recording chassis are both built for full plug-in service, and can be interchanged with each other in a matter of seconds.

Offered in either potentiometer or A-C bridge models, the new instruments can be used to measure and indicate or record any variable which can be converted into an electrical quantity, such as temperature, pressure, flow, speed, pH, smoke density, resistance, etc.

Additional information is available in Bulletin P1271.

IMPROVED CONVEYOR LINE MARKER

Krengel Manufacturing Co., Inc., 227 Fulton Street, New York 7, N.Y. has announced a newly improved series of conveyor line markers for imprinting on boxes, cartons and other objects. Simple and inexpensive, the 2-ARC Series Marker quickly and automatically imprints names, coding or dating on objects as they pass at conveyor line speeds. Quick-change rubber type legends or designs up to 4 inches high and 15 inches long are employed. Inking and distribution rollers, together with the marking roller, are actuated entirely by the passing object. The marker is available for side, top or bottom marking, or with proper brackets can be adjustable for all positions. Special units are available for unusual marking problems.

NEW FURNACE

The L & L Manufacturing Company, 136—8th Street, Upland, Delaware County, Pennsylvania, announces a new furnace designed for many industrial heating operations such as annealing, heat-treating, normalizing, annealing of glass, etc. Temperature range is from 300°F. to 2200°F.

The interior dimensions of this furnace are 40″ wide x 36″ high from top of hearth plate to spring of arch; 44½″ to center of arch x 72″ deep. Firing chamber temperature gradients are easily controlled by means of a system of input controllers, zone located thermocouples, a recorder controller and a thermocouple selector switch. There are four zones, the input to each is separately controlled by means of an infinitely variable input controller so that fine gradient adjustments can be easily made and maintained. By this means control over heat-up time, cooling time and other heat curve adjustments may be made.

Completely automatic control is attained by a combination of temperature controller with "straight line" adjustments and a precise thirty hour timer. The elements are supported by means of specially designed "Dyna-Glow" element holders (patent pending). These element holders have excellent heat transfer properties. A low mass characteristic keeps overshoot and undershoot of the temperature control point due to minimum heat storage in the element holders to an absolute minimum. Further information is available direct from the company.

CATALOGS RECEIVED

Bausch & Lomb Optical Company, 635 St. Paul, Rochester, New York are offering latest information on a wide variety of special lenses, prisms, and reflectors for industrial uses, in a 16-page catalog (L-117) of optical parts.

The catalog also contains information on ground glass, heat absorbing glass, retardation plates and the Bausch & Lomb precision glass engraving and optical coating services. A new price list detailing up-to-date individual part prices, discount procedures, minimum ordering quantities and terms of sale is included.

Solvay Process Division, Allied Chemical & Dye Corporation, 61 Broadway, New York 6, N.Y. has announced a revised, enlarged edition of their technical and engineering service bulletin #11—"Water Analysis".

This 100-page bulletin contains separate sections on the analysis of various types of water. It includes numerous tables of analytic data, conversion factors and turbidimetric and color standards, and a special section on the preparation of reagents, indicators and standard solutions used in analyses.

Fisher Scientific Company, 498 Forbes Street, Pittsburgh 19, Pa. have published the summer issue of "The Laboratory" (vol. 25/no. 2). The 32-page booklet contains a variety of topics, from a feature article "Psychochemistry" a survey of what the issue calls the newest science, joining psychiatry to chemistry, to the lab world's first unitized distillation apparatus (pat. appl. for), to a discussion of the first 100 per cent noiseless, accident-proof and fingertip-controlled blastburner for laboratory glasswork, to unitized lab sinks, to descriptions of new chemicals and many scientific tools. The booklet may be obtained direct from the company.

The Hays Corporation, Michigan City, Indiana, have issued a new 24-page color catalog giving pertinent data on the Hays line of power plant instruments and control systems. This catalog contains photos and schematic drawings of combustion guides; draft gages; flow, level, temperature and pressure instruments; combustion control systems and panels. Write for Publication 55-605-83.

Precision Glass . . .

(*Continued from page* 667)

to the low expansion borosilicate types. These tend to minimize breakage due to thermal shock or calibration change due to excessive thermal expansion.

Low expansion borosilicate glasses are difficult to manufacture because the necessary high silica and boric oxide content which is responsible for the low thermal expansion and good glass stability produces viscous sluggish glass requiring excessively high temperatures to properly melt and fine. As the silica content is increased from about the 70 per cent found in the usual soda-lime-silica glasses to the amounts (Table 1) found in low expansion glasses (usually above 75 per cent), an increase of several hundred degrees F. in furnace operating temperature would be required to produce equivalent viscosities. Such a temperature would result in differential volatilization of batch constituents, would increase refractory solution and spalling, and generally shorten the furnace life. Consequently, most glass tanks for low expansion borosilicate glasses are operated at an optimum temperature designed to produce a practical yield of a glass which is indispensable for many applications but which leaves much to be desired from an appearance viewpoint.

TABLE I—Approximate Compositions of some soda-lime-silica and low expansion borosilicate glasses

	Plate Glass	Window Glass Fourcault Process	Comm. Soda-Lime	Pyrex #7740	Kimble N-51	Monax	Vycor	Fused Silica
SiO_2	71.5	70.4	74.0	80.5	74.7	75.0	96.	100
B_2O_3				12.9	9.6	11.2	3.	
Na_2O	13.4	12.78	17.1	3.8	6.4	6.3		
K_2O	0.1	0.16		0.4	0.5	1.2		
CaO	12.5	12.14	5.8					
MgO	0.3	1.77	3.1		0.9	0.5		
BaO		0.30						
ZnO					0.1	2.8		
Al_2O_3		1.92		2.2	5.6	3.0		
Fe_2O_3								
As_2O_3	0.9	0.98						
Thermal Exp. X10-7cm per cm per°C. 0°C-300°C App.	99.		107.	32.	50.	44.	8.5	5.5

Most raw glass tubing today is manufactured in the tank in which the glass is melted. In the Danner process the tubing is made by flowing a cooled viscous stream of glass onto a hollow rotating mandrel at the working end of the tank. An air stream blown through the mandrel keeps the bore of the tube from collapsing until the glass is sufficiently cool and rigid to support its own weight as it is drawn horizontally along a series of rollers. A Vello orifice method is also sometimes used, and for larger sizes an updraw method is required.

In any event, the quality of the low expansion borosilicate glass reflects its composition and its mode of manufacture. Thus, the familiar bubbles and "seeds" defects which occur in container and optical glass occur here as thin long drawn out air cylinders known as air lines. When the original bubble is small, the drawing operation produces a short attenuated air pocket called a "dog hair".

When glass with air lines or dog hairs is reformed over a mandrel, the expanded air or entrapped moisture may cause the airline to pop and rupture the exterior or interior surface, rendering the tube unfit for its intended use. A "dog hair" in the interior of the glass may, under the influence of the reforming flame, tend to assume a minimum surface, namely the spherical bubble of its previous fluid history. However, as the flame travels past the "dog hair" the temperature decreases, viscosity increases, and left behind is an intermediate pearlike shape of the "dog hair" transitioning to sphere (Fig. 5).

Since the homogenizing activity of the low expansion borosilicates is hampered by its excessive viscosity, a large amount of striae is invariably found in this type of glass. Most of such striae occur as interior cylindrical envelopes of ream striae and as such is acceptable for reforming purposes. Occasionally, a heavy concentration of the striae occurs at one portion of the periphery, forming a narrow zone along the length of the tube which may result in a weakened tube. Another form of cord is hairpin cord. It generally runs parallel to the axis of the tube and takes the form of a long line with a sharp V at its end as it reverses direction. Unless these are quite heavy, their offense is more against the appearance than the strength of the tube.

Stones are crystalline aggregates usually formed by loosened refractories or small built up patches of undissolved or inhomogeneous batch or even devitrified glass which acretes as it preferentially dissolves some of the surrounding constituents and shows up in the raw glass tube as a small hard lump or stone. Small or flaky stones are not too significant. Large solid ones, or any that penetrate the inner surface of the glass are not acceptable. The former would be undesirable because its thermal expansion, generally quite different from the parent glass, might cause dangerous strain and the latter might cause damage to the mandrel.

Crystallites are small crystalline particles usually less than a half millimeter in length. These are often undissolved silica grains or powdered refractory grains. Their main contribution is to give the tube a spotted dirty appearance and to make the glass containing them unsuitable for use with photometric or photoelectric optics as in absorption cells or scanned manometer tubes.

Due to their unequal expansion compared to glass, crystallites may break off from the glass surface, leaving small conchoidal fracture marks that could have a weakening effect on the glass.

Reforming Glass

In the reforming of precision bore glass tubing, prime importance attaches to the mandrel with respect to its material, dimensioning and finish. The materials used for mandrels are selected stainless steels and high temperature alloys to suit the particular glass. Before the accurately dimensioned and highly finished mandrel is put into use it is uniformly heat treated to produce a continuous hard oxide protective layer which also inhibits sealing.

Since the heat of the reforming torches produces severe thermal stresses, it is necessary to anneal the raw glass tubing before rundown, especially in the larger sizes. The rough semi-annealing that the tubes receive when they are manufactured is adequate for ware below about 1 in. I.D. but not for larger or heavy wall tubes.

In fabricating the precision-bore tubing the mandrel is mounted on a glass lathe which may be of a horizontal

or vertical type. The mandrel is set into rotation and then preheated throughout its length with a flame or an R.F. actuated coil. It is necessary to preheat the mandrel not only to minimize thermal shock, but also to expand the metal mandrel so that the reformed glass will be to full size. When the mandrel has been adequately preheated, the raw glass tube is placed over it and capped with a packing so that the air between the glass tube and mandrel can be evacuated through an orifice at the outlet end of the latter.

Upon completion of evacuation, the glass tube is heated with an air-gas or oxygen-gas flame starting at the end opposite the orifice. As the glass softens in the heated zone, atmospheric pressure causes it to collapse into intimate contact with the mandrel along a peripheral clump known as the "drop," (center of Fig. 6). By slowly traversing the mandrel past the flame the "drop" is continued until the entire working portion of the tube has been shrunk to the mandrel. The fit between the shrunken glass and mandrel is so tight that once the drop has occurred, the upper packing may be removed (as in Fig. 6) without affecting the vacuum. The rotating action of the mandrel also has an effect on the molten glass, producing a thicker wall and rounder O.D. This considerably increases the strength of the tube.

After reforming, the glass and mandrel are permitted to cool. The latter with its higher expansitivity undergoes a greater contraction during cooling than does the glass. This permits it to be removed rather readily. Occasionally, it might be necessary to use a parting fluid to facilitate separation. As soon as the tubes have been taken off the mandrel, they are removed for processing in a batch type annealing oven.

Devitrification

Since glass exists as glass at temperatures below its liquidus because of its extreme viscosity, it is not surprising to have it revert to its stable crystalline condition when its viscosity is decreased as a result of heating operations. Thus, when some glass compositions are annealed at their upper annealing range, devitrification may occur, resulting in a cloudy semi-opaque glass crystal mixture. Annealing schedules have to be adjusted to avoid this, especially with the less stable glasses.

An even more critical time for devitrification occurs during reforming when the temperature of the outer surface of the glass may approach that of maximum crystal growth. This interval generally occurs approximately 50° C. to 150° C. below the liquidus temperature[3]. To inhibit the onset of crystallization a rapid rate of cooling should be used. The occurrence of cold cracks due to rapid cooling can be avoided by arresting the rapid cooling at the upper portion of the annealing range and then cooling slowly. The situation with respect to devitrification is further complicated by the fact that the outer surface is usually deficient in B_2O_3, Na_2O, K_2O, etc. This can be helped by treating the glass with sodium perborate and other solutions.

Annealing

In most of the glass industry, the term annealing of glass refers to the removal of much of the strain imparted to the glass during the fabricating process by a heating, holding and cooling operation conducted either in the oven or on the continuous moving belt of a lehr. When the strain birefringence has been reduced to about 40 to 80 mμ/cm the ware is considered annealed. For most of the glass industry (container ware, flat ware, etc.) this type of annealing is adequate.

However, this is far from the complete story; release of strain is only one of a number of changes that annealing imparts to glass. Additionally, it changes the glass dimensions, density, index of refraction, electrical properties, coefficient of expansion and others.

While these changes are too small to be significant in most of the glass industry, the situation is quite different with precision glass. Since these annealing changes can amount to 50 per cent of the permissible dimensional tolerance, their consideration is quite vital in the manufacture of precision glass.

Thus, when a small sample of a normal glass is heated sufficiently at a given constant temperature within its annealing range to permit the equilibrium state of that temperature to be obtained, and then chilled rapidly to room temperature, the glass will in effect have "frozen in" a complete set of physical characteristics like density, refractivity, size, etc., corresponding to the temperature from which it was quenched. If the same process is repeated for other temperatures in the annealing range, different room temperature values will be obtained for these properties. Thus, within small limits (about .001 in. to .0001 in.) the actual physical dimensions of a glass article can be altered.

In practical cases, the size of the ware is usually too large to permit rapid chilling without excessive permanent strain or breakage. Consequently, as the article is slowly cooled it acquires different amounts of the various temperature states below it and at room temperature corresponds in size to some resultant integrated value depending upon the cooling rate used. This imposes a

(*Continued on page* 688)

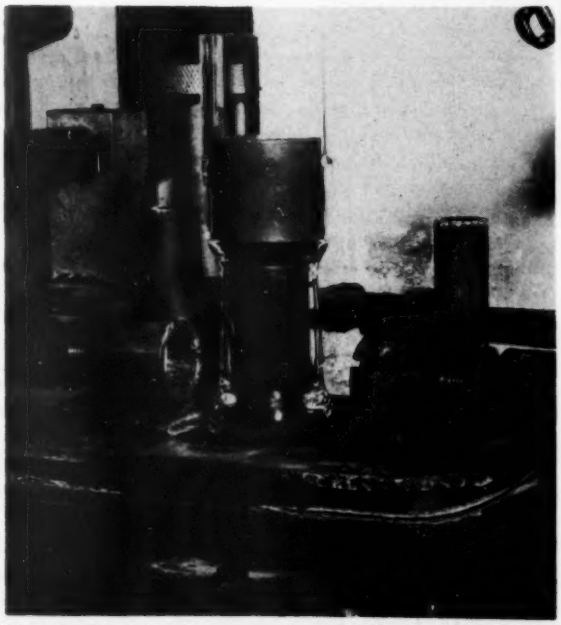


Fig. 6. Precision bore glass tube being reformed over mandrel.

GCMI Meets in Phoenix . . .
(*Continued from page* 665)

Left to right: H. B. McCoy, Deputy Administrator BDSA Department of Commerce, E. F. Ball, S. B. DeMerell, The Honorable Barry M. Goldwater, U. S. Senator from Arizona, R. L. Hall.

Left to right: H. C. Herger, P. G. Fuger, R. L. Cheney.

"This increase in demand stems mainly from the likelihood that the pattern of successful development of new uses and new markets for glass containers will continue during 1957", Mr. Merrifield said. "Such growth has been particularly evident in the shipments of glass containers to the food industry, soluble coffee and baby food packaged in glass serving as examples".

"A pattern of glass container shipments similar to that observed in the food industry has been evident in shipments of medicinal and health bottles," Mr. Merrifield said. "There are several elements of strength in this market for glass containers, particularly in the development of new antibiotics. In particular, whenever the actual medicine or drug comes into direct contact with the container, glass is usually the most efficient container", he stated.

Pointing out that areas of strength in the use of glass for packaging toiletries and cosmetics were particularly evident in the perfume and lotion fields, Mr. Merrifield predicted that shipments of glass containers to the toiletry and cosmetic industry are apt to rise about five per cent above the estimated 1956 level in 1957.

"Glass container shipments for packaging alcoholic and non-alcoholic beverages have followed established trends in 1956", the economist said. "In both returnable and non-returnable beer bottles a position of equilibrium relative to competing types of packaging has been at least temporarily established, and total shipments of glass containers to the beer industry in 1957 are apt to be close to the corresponding 1956 levels", Mr. Merrifield stated.

Other Institute activities such as the packaging research program to be carried on at Michigan State University and the continuance of research work at the Preston Laboratories, Butler, Pennsylvania were discussed.

An increase in the present fellowship at the University of Massachusetts, where processing studies and other work is carried on under GCMI sponsorship was approved.

Two able guest speakers held the attention of the members during the three-day meeting. On the first day the Honorable Barry M. Goldwater, United States Senator from Arizona spoke on "The Importance of Businessmen in Politics."

At the close of the Thursday session, John M. Fox, president, Minute Maid Corporation, delivered an inspiring address "The Greatest Need of American Business —Management".

On the social side, the meeting surpassed expectations. Sunshine and cloudless skies for golf, swimming and riding. The "Home on the Range" party was a great success and the GCMI cocktail party, banquet and excellent floorshow was enjoyed by all.

Left to right: S. L. Rairdon, H. W. Kuni.

Left to right: Mrs. J. E. Bellinger, Mrs. W. P. White, Jr., Mrs. Lowell Roesner, chairman of ladies committee.

KAISER DEDICATES NEW BASIC PLANT

E. W. Adams

F. M. Cashin

The new basic refractories plant at Kaiser Aluminum & Chemical Corporation's Chemicals Division was dedicated recently in colorful ceremonies sponsored jointly by the company and the Chamber of Commerce.

The five-million dollar facility, which has been under construction for more than a year, has commenced operations and is now supplying basic refractory brick, ramming mixes and furnace grains to the steel, cement, glass and copper industries in the East and Middle West.

The dedication ceremony climaxed a day-long celebration which drew thousands of residents of Columbiana and the surrounding area. Plant tours were conducted throughout the morning and afternoon. Over 1,500 pounds of beef were served at a public barbecue held at noon in Firestone Park. Guests included company officials and state and local leaders.

Frank M. Cashin, vice president and manager of Kaiser Chemicals Division, declared during the brief dedication:

"This expansion of our production facilities reflects our confidence in the continuing growth of the steel, glass, cement and non ferrous industries who are the major users of our refractories," he continued, "and location of our plant here at Columbiana represents a significant step for the Kaiser Chemicals Division.

"This strategic location, so close to the geographic center of the nation's great industrial areas, will permit us to give considerably improved service to our eastern and mid-western customers who previously were supplied from our California facilities. Our new plant here will shorten delivery time in some cases by as much as 14 days."

The plant covers more than three acres and is located on a 185-acre site on the main line of the Pennsylvania railroad and within a few miles of the Ohio-Pennsylvania Turnpike.

Included are facilities for receiving and storing raw materials; grading, drying, classifying and mixing ingredients; pressing, drying and burning brick, and checking and shipping finished product. Also included is an extensive laboratory for quality control, machine shop for servicing the plant and a separate administration building.

When additional equipment now on order is installed by the end of this year, the plant's annual capacity for basic brick, aside from ramming mixes and furnace grains, will be 48,000 tons.

Periclase is being supplied from Kaiser Chemicals Division's fully integrated raw materials plants in California. Chrome ore is imported from the Philippines.

Periclase is shipped to Columbiana in covered hopper cars. There it is discharged and transported by conveyor belt to the main storage tanks.

Production of basic refractory products at Columbiana begins with crushing and screening of the periclase. It is separated into various size fractions and then weighed and mixed to the required composition of a particular product.

The mix is gravity fed by hoppers to presses which form it under pressure into basic refractory brick.

The brick are shipped in bulk or on pallets by truck or rail. Loose materials like ramming mixes, bonding mortars and furnace grains are shipped either in bulk or in 100-pound sacks.

Plant manager of the new Columbiana facility is E. W. Adams, who has been with the company for 13 years and has been associated with its chemical operations during most of that time.

DR. P. J. FLORY NAMED NEW HEAD SCIENTIFIC RESEARCH IN MELLON INSTITUTI

Dr. Paul J. Flory, eminent scientist of Cornell University where he is Professor of Chemistry and Acting Chairman of the Department of Chemistry, has been chosen to head Mellon Institute's investigational activities as Executive Director of Research. This announcement by General Matthew B. Ridgway, chairman of the board of trustees and chief administrative officer of the Institute, indicated that Dr. Flory will join the organization for a day a week during this fall, half time in February, and full time in the summer of 1957.

In this new position of research leadership in Mellon Institute, a post that has been established since the recent retirement of Dr. Edward R. Weidlein as president, Dr. Flory will be principally responsible for mapping and guiding the investigational future of the Institute.

Dr. Flory has had a distinguished career in research, having spent twelve creative years in the chemical and allied industries and ten fruitful years in the field of scientific education with much accompanying investigational work. He has pioneered research on the constitution and properties of substances comprised of giant molecules, such as rubbers, plastics, fibers, films, and proteins, and is the author of 106 papers in scientific journals, all of which have been original contributions to chemical and related literature. A 670-page book, his *Principles of Polymer Chemistry*, published in 1953, is a respected treatise. Twenty-two patents have been issued to him, inclusive of instances of co-invention.

Dr. Flory was educated at Manchester (Ind.) College and at the Ohio State University (M. S., 1931; Ph. D., 1934). In 1950 Manchester College conferred on him an honorary Sc. D. Following the completion of his graduate work at Ohio State, where he majored in physical chemistry, Dr. Flory embarked upon research on synthetic fibers, synthetic rubbers, and other polymeric substances.

In addition to his illustrious research work on high polymers, Dr. Flory is well known professionally for his notable investigational accomplishments in photochemistry, chemical reaction kinetics, thermodynamics, and statistical mechanics.

PENNSYLVANIA GLASS SAND AWARDS TEN SCHOLARSHIPS

Merit Award Scholarships were recently presented by the Pennsylvania Glass Sand Corporation to ten outstanding ceramic engineering students who attained high scholastic averages for their junior year's work at their respective schools. The awardees were chosen by the Scholarship Committees of the various universities and, under the provisions of the Pennsylvania Glass Sand Scholarship Program, full tuition for the senior year in ceramic engineering was presented to each of the participating schools.

The following students are currently holding Pennsylvania Glass Sand Merit Award Scholarships for the 1956-57 school year: Richard L. Lane, Alfred University, Norris A. Hooton, Clemson College, Carl Howard Swanson, Georgia Institute of Technology, John Doornward, Iowa State College, Roy T. Smith, University of Missouri, Robert K. Ware, University of Texas, James R. Keski, University of Washington, and David H. Hubble, Virginia Polytechnic Institute. At the University of Illinois, David Kessel and Robert D. Shannon are sharing a Pennsylvania Glass Sand Scholarship, each receiving tuition for half of the school year. Ohio State University, Pennsylvania State University and Rutgers University, although included in the Scholarship Program, were unable to participate this year.

Commenting on the Pennsylvania Glass Sand Scholarships, Mr. William J. Woods, Jr., vice president, said, "We firmly believe in the future of the ceramic industry and are convinced that in the years ahead many new and remarkable ceramic products will be developed by present-day ceramic engineering students. We are indeed pleased to provide scholarship assistance to these students and wish them continued success in the rapidly expanding ceramic industry."

PITTSBURGH PLATE INCREASES SCHOLARSHIP

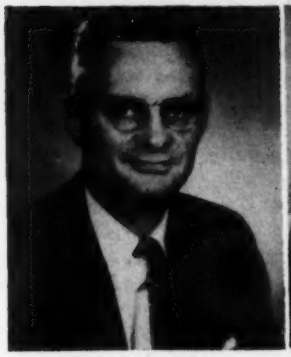
Pittsburgh Plate Glass Company announces that its annual four-year science and engineering scholarship program offered in its window glass producing plant town at Mount Vernon, Ohio, has been revised this fall to allow future award winners increased tuition benefits.

The revised scholarship program will provide the award winner with a scholarship valued at $2,000 plus four-year's tuition. Previous Pittsburgh Plate award winners received four-year scholarships valued at $4,000 which included tuition costs. The new tuition provision gives the winner a wider selection of technical schools from which to choose the accredited college or university where he intends to obtain his training for a science or engineering career.

• Ronald Prachel, Rochester Institute of Technology and William Steve, St. John Fisher College, joined the staff of the Glass and Organic Sections respectively of the Bausch & Lomb Chemical Research Laboratories.

• E. J. Rhein, sales manager of the scientific glassware division of Kimble Glass Co., subsidiary of Owens-Illinois, has been re-elected as a director-at-large of the Scientific Apparatus Manufacturers Association.

O-I PROMOTES THREE EXECUTIVES



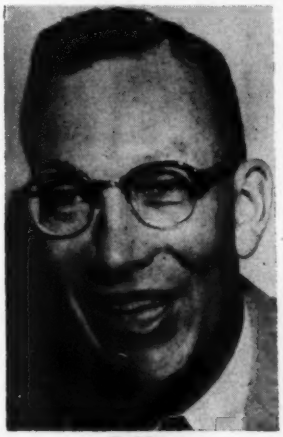
M. G. Beishline

R. A. Cosh

Promotions for three key executives on the production staff of the Owens-Illinois Glass Company's Glass Container Division were announced by C. G. Bensinger, company vice president and president of the Glass Container Division.

The announcement followed Mr. Bensinger's appointment as division president, a new position, in which he will supervise the company's glass container and closure operations in the United States.

Richard A. Cosh, O-I vice president and general factories manager of the Glass Container Division, has been named assistant general manager and a member of O-I's Planning and Executive Research Committees.



E. Marr

Miles G. Beishline, division vice president and production manager, will succeed him as division factories manager and Eliot Marr, manager of the Los Angeles glass container plant, will transfer to Toledo as division vice president and production manager, succeeding Mr. Beishline. Messrs. Beishline and Marr will also serve on the division's Research and Directing Committees. The changes were effective August 15.

Mr. Cosh joined Illinois Glass Co., an O-I predecessor, as a draftsman in 1920. He was elected a company vice president and appointed division general factories manager in 1947.

Mr. Beishline's first job with Owens-Illinois was as an industrial engineer at the Alton plant in 1931. In 1953 he was assigned to division headquarters, Toledo, as vice president and production manager.

Mr. Marr joined the production and service control department of O-I's Pacific Coast Division headquarters, San Francisco, in 1934 and was promoted to manager of the production control department in 1947. He has been plant manager at Los Angeles since 1953.

• John R. Nelson, Milwaukee, Wis., has joined Owens-Illinois Glass Co., Toledo, O., as an attorney in the Patent Department.

Precision Glass . . .

(*Continued from page* 684)

limitation to the use of higher annealing temperatures.

In the direction of lower annealing temperatures greater flexibility exists. Here the limitation is mainly time. At lower annealing temperatures, the time required is greater and becomes greater yet as cooling commences. This means that starting with a low annealing temperature it is no longer necessary to cool the glass quickly since the temperatures below it require such a disproportionately longer time to even approach equilibrium that even a very slow cooling rate would only reflect the initial temperature state.

In the case of high silica content low expansion borosilicate glasses, the situation is further complicated by the fact that these glasses may exhibit a two-liquid behavior resulting in anomalous effects on expansion, density and dimensional changes.

However, by the judicious use of controlled annealing schedules, it is possible to secure ultra precise dimensioning. There is also presented the possibility of salvaging precision formed glass that would otherwise be rejected due to slight oversize or undersize. Thus, through the application of glass technology to glass fabrication, even the anomalous dimensional changes in glass annealing can be used to make precision glass more precise.

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KAHLE ANNOUNCES NEW PLANT

Executives of Kahle Engineering Company recently announced the addition of a new plant on Hudson Avenue, Union City, N. J. This new plant will increase the company's manufacturing shop area by over 300 per cent. Substantial increases will also be made in manufacturing personnel, production equipment, laboratory and experimental facilities. These new facilities are also aimed at improving delivery schedules.

The Company's General Offices will continue to be at 1400 Seventh Street, North Bergen, N. J., where manufacturing facilities are also maintained.

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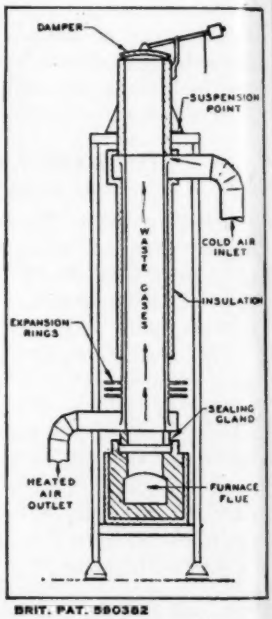

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MINTON ELECTED TO AFL-CIO COUNCIL MEMBERSHIP

The AFL-CIO Executive Council has elected Lee W. Minton, President of the Glass Bottle Blowers Association, to fill the Council membership of Matthew Woll, who died June 1st.

Mr. Minton has been head of the 52,500 members of the glass union since 1946. He joined in 1937 while working for the Hazel-Atlas Glass Co. in his home town, Washington, Pa. His rise in union ranks has been rapid, as he was only 34 when he became International President. His present age of 45 makes him one of the youngest of the 29-member Executive Council.

Mr. Minton is a life-long registered Republican. His election came a day after the Council recommended endorsement of the Democratic national ticket. In 1955, Mr. Minton was appointed by President Eisenhower to serve on the International Development Advisory Board. He also served on the Citizens Committee to study the Food and Drug Administration. He was designated by President Truman as Co-Executive Secretary of the Anglo-American Cooperation Administration and as a consultant to the State Department on European trade treaties.

NATIONAL BUREAU OF STANDARDS TO BE RELOCATED

The Congress appropriated funds for site acquisition and preliminary planning early in June after details about the proposed site had been presented to House and Senate Appropriations Committees. Plans for the site have been given to the National Capital Planning Commission and to the Regional Planning Council, and it is expected that these groups will work with the Bureau in utlizing the land. The General Services Administration will participate in planning and will supervise construction. Transfer of operations to the new location is expected to be completed in about five years.

A tract of approximately 550 acres of land near Gaithersburg, Maryland has been selected for relocation of the Washington laboratories of the National Bureau of Standards. The move will permit the Bureau to plan new buildings to replace present research facilities, which over the past 50 years have become inadequate.

J. C. BUTLER ELECTED TO MEMBERSHIP CONTROLLERS INSTITUTE OF AMERICA

James C. Butler, controller and assistant treasurer, Latchford-Marble Glass Company, Los Angeles has been elected to membership in the Controllers Institute of America.

Established in 1931, the Institute is a non-profit management oragnization of controllers and finance officers from all lines of business—banking, manufacturing, distribution, utilities, transportation, etc. The total membership exceeds 4,500.

• Rushmore H. Mariner has been appointed director of real estate operations for Corning Glass Works. Mr. Mariner will be responsible for all real estate operations and transactions by the company. His former position was manager of the Contract Sales Department in the Consumer Products Division.

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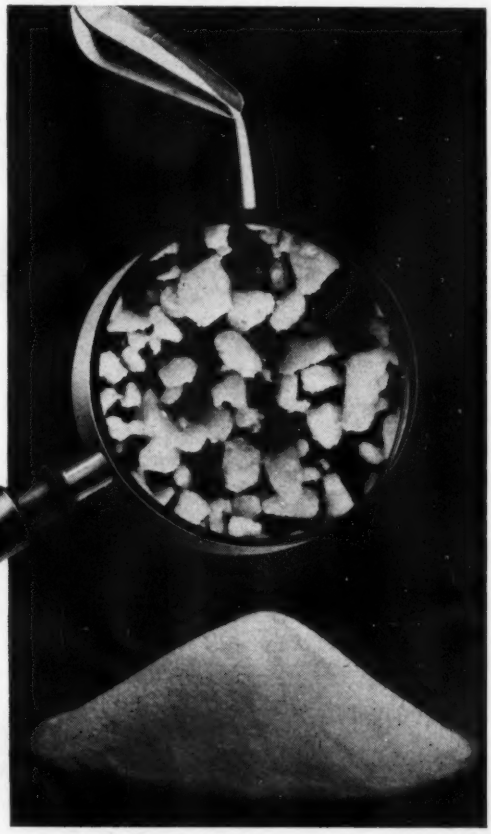
Your Refractories Benefit
when you *Specify* **SOLVAY**
POTASSIUM CARBONATE
because it's the potassium carbonate
that's **DUST FREE**



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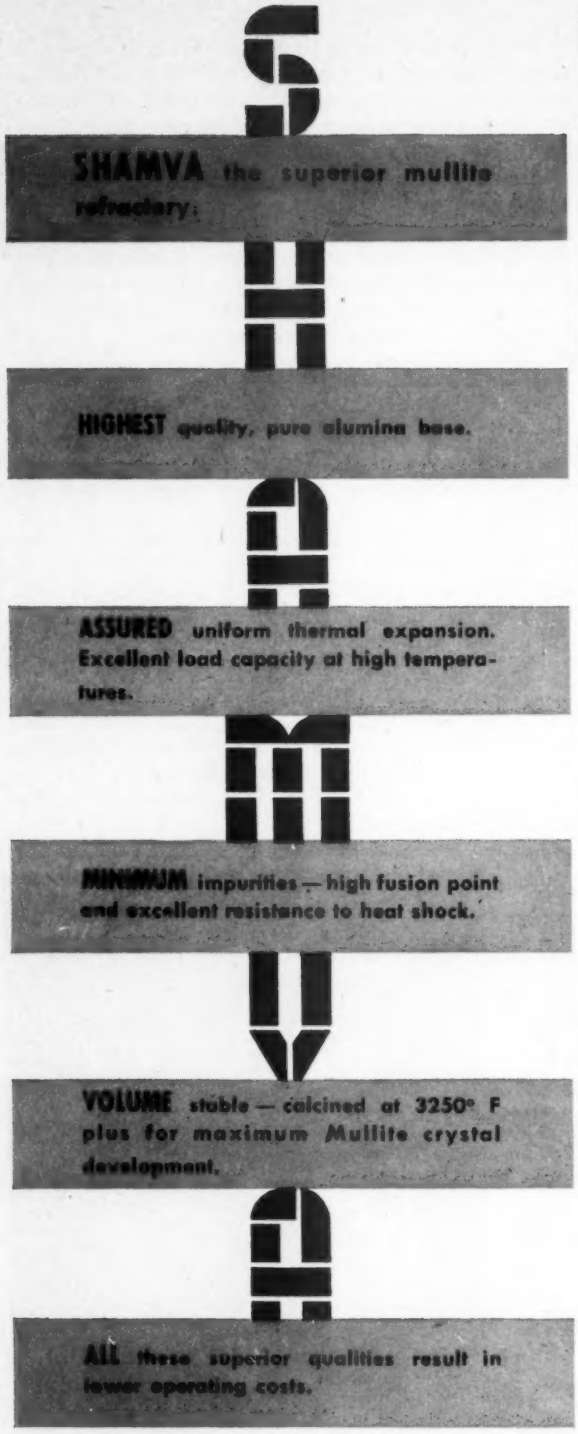
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Cords in Glass . . .

(*Continued from page* 674)

of furnace design and fire control. The maintenance of a positive pressure in the tank helps in securing a more uniform temperature distribution. The critical nature of the glass level in the tank has been discussed by Griffin, Light, and Russell (1950). Hampton (1948) showed that some variation in level increased the life of wall blocks.

The role of surface and interfacial tensions in glass melting has already been discussed. Since the surface tension of some glasses may increase as much as 20 per cent under reducing conditions, as compared with an oxidizing atmosphere, the nature of the fire influences the homogenization processes in the melt, as well as the color of the glass.

Modifications in the firing of the furnace can sometimes be made to compensate for trouble in the charging of batch and cullet. Stray batch piles, for example, can usually be held back by a strong fire in the ports at the end of the batch zone.

Conclusion

There is no one magic solution to the problem of cords. The most effective means of producing good quality homogeneous glass on a commercial scale is to combine good over-all control of the batch house and melting furnace with close coordination of factory observations and laboratory tests. The maintenance of density and other control charts is a useful method for keeping track of the performance of the batch house. Troubles originating with the furnace refractories are often more difficult to correct than those originating in the batch house. Careful study of the furnace after it has been shut down is essential to the planning of modifications intended to improve its performance.

Sometimes the origins of cords can be definitely located and the trouble remedied; often the sources are difficult to determine. Some cords disappear in time even though no corrective measures are taken; others persist in spite of all efforts to eliminate them. The best insurance against cord troubles is strict adherence to the principles of good glass-factory practice.

Acknowledgment

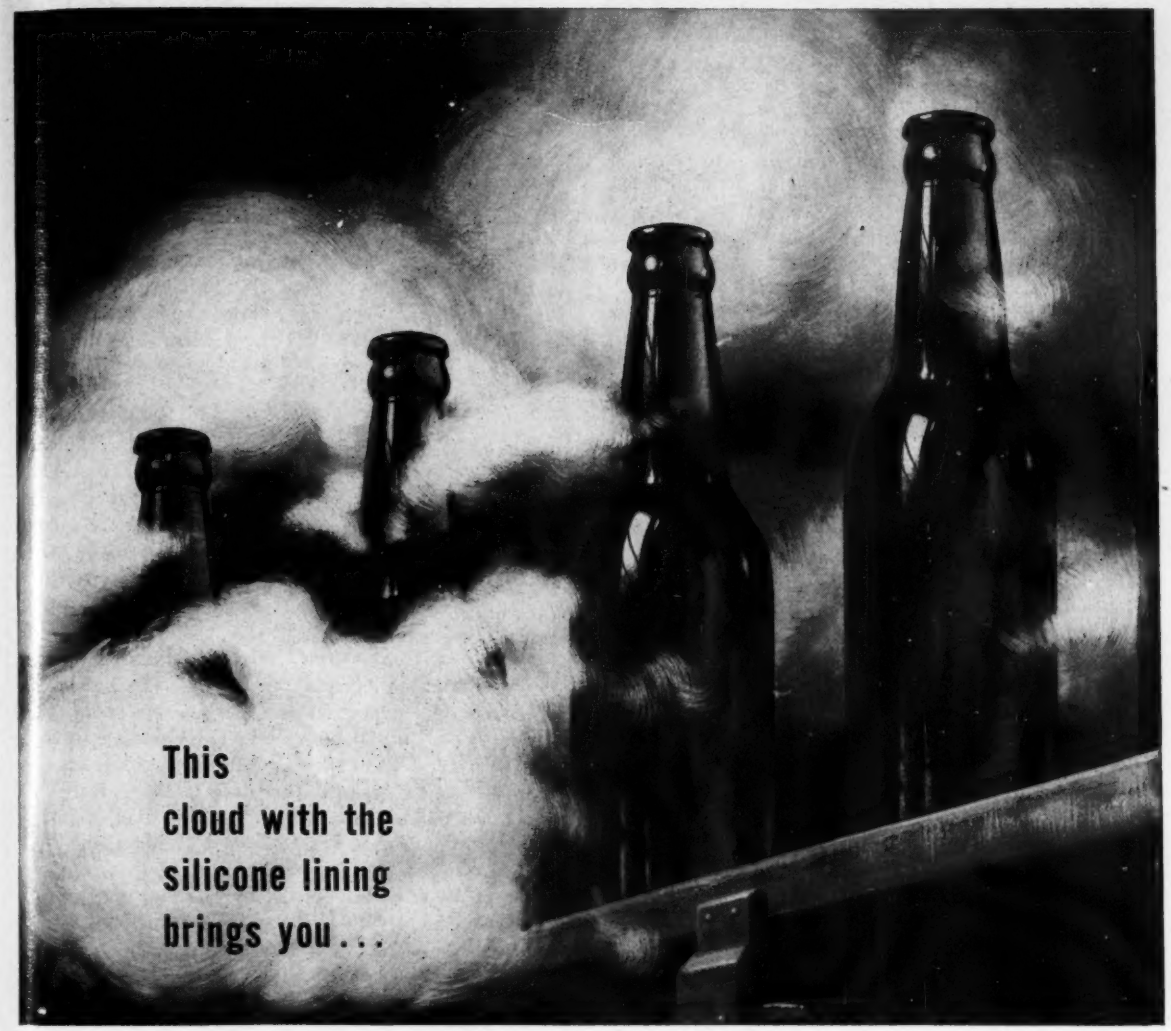
Dr. J. L. Glathart, Albion College, Albion, Michigan, formerly of the Preston Laboratories, has contributed much to the reorganization of this report. The writer is grateful to him and to a number of other friends, too numerous perhaps to be mentioned individually.

ANCHOR HOCKING TO BUILD NEW GLASS CONTAINER FACTORY

Mr. Wm. V. Fisher, president, Anchor Hocking Glass Corporation, Lancaster, Ohio has recently announced that necessary acreage has been secured and plans completed for the building of a new glass container factory in San Leandro, California on a 23-acre tract.

The Corporation will build a warehouse immediately. A modern, completely integrated facory building is to follow as soon as the warehouse has been completed. This will be designed and built to accommodate two 150-ton furnaces. Manufacturing operations, however, will start with the completion of the first furnace.

The new plant will manufacture a complete line of wide mouth and narrow neck glass containers for food products, wines, liquors, beers, carbonated beverages, drugs, pharmaceuticals and household chemicals.



LOW COST ANTI-SEIZE TREATMENT

Glass container manufacturers are fast turning to UNION CARBIDE silicones to reduce bottle breakage. Sprayed on as a fog or mist right in the lehr, these powerful anti-seize agents impart excellent lubricity to the outer surfaces of containers.

The cost of silicone anti-seize treatment is low—more than offset by savings in the costly and troublesome breakage that can occur during handling and filling. The first step is the preparation of a 0.5 to 1.0% aqueous solution of the UNION CARBIDE anti-seize agent. This water-like liquid is then applied as a fine mist in the lehr, using fogging equipment supplied by many reputable manufacturers. The result . . . a light even coating that insures a shiny, attractive container.*

The glass industry also depends on the "slipperiness" and water repellency of UNION CARBIDE silicones in another phase of production. They help produce sparkling bottles with fewer rejects when used as a lubricant on molds, shear blades, and chutes. Less soot, less smoke . . . working conditions are vastly improved.

Contact Silicones Division engineering staff for advice and service on the proper use of silicone anti-seize agents in your plant. *And,* be sure to ask them about X-520 for anti-seize treatment of food containers.

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☐ **Bulletin #2762A** — Crack-off And Glazing Machine. Automatically cuts and glazes glass tubing.

☐ **Bulletin #2739** — Sealed Beam Lamp Equipment. Describes pilot plant Machinery and techniques.

☐ **Bulletin #1233** — Automatic Lamp Finishing Machine. Bases, trims wire, fluxes, solders, flashes and unloads bulbs.

☐ **Bulletin #2461** — Glass Body Making Machine. High speed producer of micro-miniature glass bodies.

☐ **Bulletin #1708** — Automatic Neck Sealing Machine. Makes Vacuum (Thermos) bottles, dewar flasks, etc.

☐ **Bulletin #1507** — Horizontal Crack-off and Glazing Machine. High speed cutter; up to 15,000 pieces/hr.

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DR. R. R. SHIVELY DIES, WAS DRAKENFELD OFFICER

The death of Dr. Robert Rex Shively, director and former vice president of B. F. Drakenfeld & Co., Inc., has been reported. Dr. Shively, 73, died at his home in Mt. Lebanon, Pa., after a long illness.

Dr. Shively was well known throughout the glass and ceramic industries for the many contributions he had made to technological advances. Among them were the development in 1913 of a highly efficient illuminating glass, still outstanding in its field, and the use of selenium as a decolorizer. He also was the first in this country to use neodymium in making commercial glass for art and tableware. The continuous production of colored glass in pots and tanks was also attributed to Dr. Shively.

The Drakenfeld officer retired July 31, 1954, as manager of the company's Washington, Pa., plant but continued to serve as a director of the company.

Dr. Shively was born in Eldorado, Kan., and moved by covered wagon with his parents to Oklahoma Territory when he was a child. In 1902 he was graduated from Oklahoma A. & M. and from 1905 to 1908 was an assistant in the school's Department of Chemistry. (On its 50th Anniversary in 1941, the school paid a tribute to his accomplishments in his profession by naming him one of the first three to its Hall of Fame.)

In 1908 Dr. Shively was appointed as scientific assistant in the Bureau of Chemistry, Dept. of Agriculture in Washington. During his residence in the capital, he attended George Washington University and specialized in chemistry. As a Fellow at Mellon Institute, Pittsburgh, in 1911, he did important research work in glass and served as an assistant director of the Institute, and two years later earned his Ph. D. degree from the University of Pittsburgh. From 1918, when he left the Mellon Institute, to 1922 he was in charge of the laboratory and furnace operations of the Monongah Glass Company, Fairmont, W. Va.

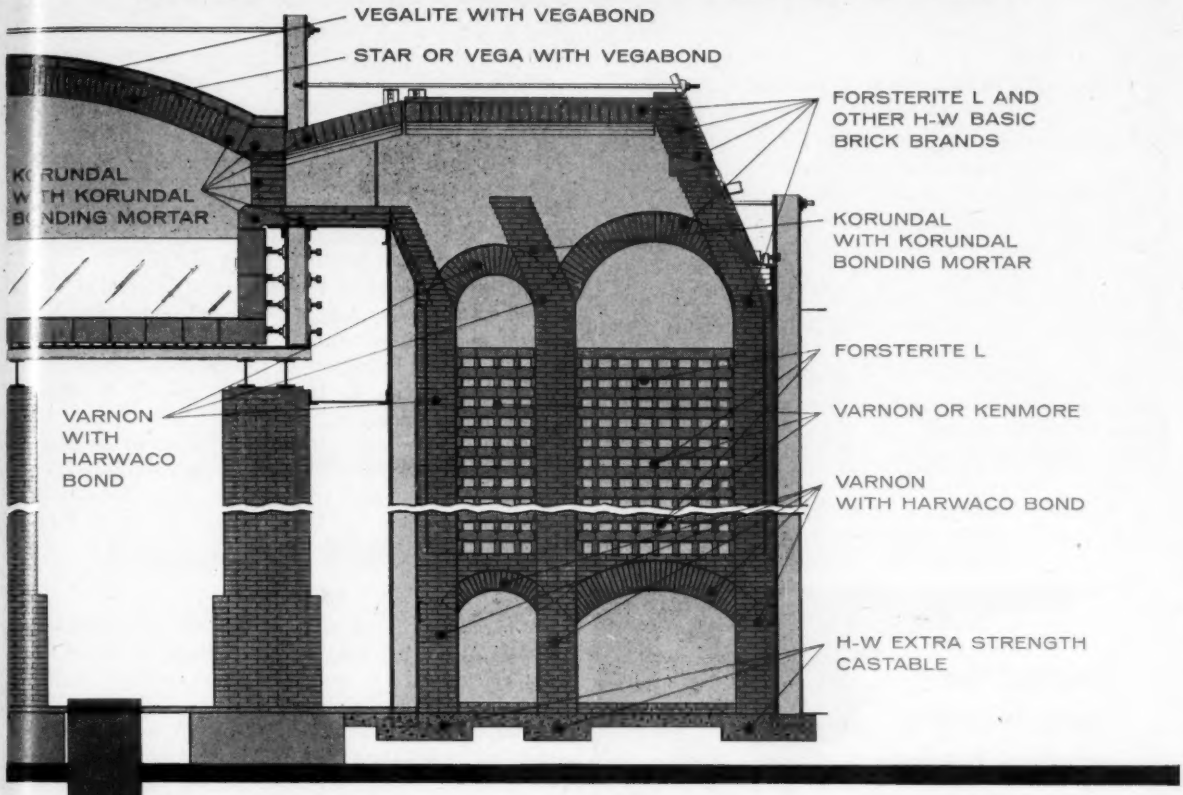
He joined B. F. Drakenfeld & Co., Inc., in 1922, as chief technologist. One of the first things he did in his new capacity was to inaugurate color research service for Drakenfeld customers. It was also at Drakenfeld that he perfected some of his contributions to the industry. In September, 1952 Dr. Shively, by then vice president and plant manager of the Washington, Pa., plant, was tendered a 30th anniversary celebration by his colleagues.

Dr. Shively was a Fellow in the American Ceramic

(*Continued on page* 694)

...get longest campaigns ... when refractories are *in balance*

Typical brand selection for severe conditions in soda-lime glass furnace


VEGALITE WITH VEGABOND
STAR OR VEGA WITH VEGABOND
FORSTERITE L AND OTHER H-W BASIC BRICK BRANDS
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FROM the complete range of Harbison-Walker refractories especially suited for glass tank superstructure requirements, you can select the specific types and classes that will assure maximum service in each position. Knowing your particular operating condition, such as batch characteristics, temperatures, and related factors, you can select for the crown, regenerators and other furnace parts, the Harbison-Walker refractory that will best fulfill the need, thus achieving the balance that results in longest campaigns and maximum economy.

Harbison-Walker freely offers the cooperation of the Technical Service Department in choosing the types and brands of refractories that will give the most satisfactory service in your glass tank furnaces.

Some Harbison-Walker Leading Brands

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SILICA BRICK—Star, Vega—Super-duty quality.

HIGH ALUMINA BRICK—H-W Corundum—99% Al_2O_3, Korundal—90% Al_2O_3, Coralite—80% Al_2O_3, H-W Mullite—70% Al_2O_3, Anchor—60% Al_2O_3, and Dialite—50% Al_2O_3.

SUPER-DUTY FIRECLAY BRICK—(Varnon, Alamo from Mo.) (Kenmore-Boone from Ky.) (Dean from Pa.) (H-W Super Savage from Md.) (H-W Kala from Ala.)

HIGH-DUTY FIRECLAY BRICK—(Benezet, Woodland from Pa.) (Walsh XX from Mo.) (High Grade from Ky.) (H-W Crown from Ala.) (H-W Savage from Md.) (Coleman XX from Tex.)

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Dr. R. R. Shively . . .
(*Continued from page* 692)

Society and a Fellow in the English Society of Glass Technology. He is survived by his widow, Mrs. Mary Burke Shively, a daughter, Mrs. J. H. Hillman III, of Pittsburgh, and a son, Dr. Robert R. Shively, Jr., of Houston, Texas. Funeral services were held in Castle Shannon, Pa., and burial was in Stillwater, Okla. In his memory, the Robert Rex Shively Memorial Scholarship Fund is being established at Oklahoma A. & M. It will be administered by the Fidelity Trust Co., Pittsburgh.

SLA RECEIVES GRANT FOR SCIENTIFIC TRANSLATIONS CENTER

Miss Katherine L. Kinder, president of the Special Libraries Association, has announced that a grant of $20,350 has been received from the National Science Foundation. The grant provides for the support of a Scientific Translations Center at The John Crerar Library in Chicago.

Translation Monthly, a subscription journal listing translations received by the Scientific Translations Center, will be expanded to include translations from the Russian. Items listed will be available for borrowing or photocopies may be obtained from the Science Translations Center at The John Crerar Library, 86 East Randolph Street, Chicago 1, Illinois.

Further information about the Center may be obtained from John P. Binnington, Librarian, Brookhaven National Labqratory, Upton, Long Island, New York.

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Optical Society Meeting . . .
(*Continued from page* 675)

instruments flexibility is desired not only to ease the passing of the instrument but also to allow a clear view and photographic recording of the regions which are not perceptible through the existing gastroscopes due to their limited flexibility.

For accurate manipulation and alignment of glass fibers a machine has been constructed which is capable of producing 30 inch long fiber bundles made out of 25μ diameter glass fibers. Work is also in progress on a different type of assembly of fibers termed as "light funnels." This device is used for changing the shape of an illuminated surface and has shown promise for illuminating the slit of Stellar and Raman Spectrographs. The use of light funnel for certain condensing systems is also being investigated. The possibility of appropriate assemblies of fibers for "field flattening" the image formed by a lens system and also for image dissection in high speed photography is being evaluated.

The invited paper on the fundamentals of fiber optics by N. Kapany, was followed by contributed papers on optical applications, with R. E. Hopkins, J. A. Eyer, and R. E. Keim, University of Rochester as collaborators, and by L. Curtiss, B. Hirschowitz and C. W. Peters, University of Michigan.

A well attended demonstration was given by the Bausch & Lomb Optical Co. of a model fiber optical system exhibiting fiber optics prepared by their Chemical Research, G. Sheldon, and Optical Laboratories, N. Finkelstein and collaborators.

GENERAL

A highlight of the meeting was the presentation of the Ives Medal to Professor John Strong of Johns Hopkins University, for his work in evaporated coatings (including the 200 inch Mt. Palomar mirror) and in infrared spectroscopy. The Ives Medal is awarded annually for outstanding work in optics. After the presentation Profesor Strong described current work in far infrared interferometry at Johns Hopkins.

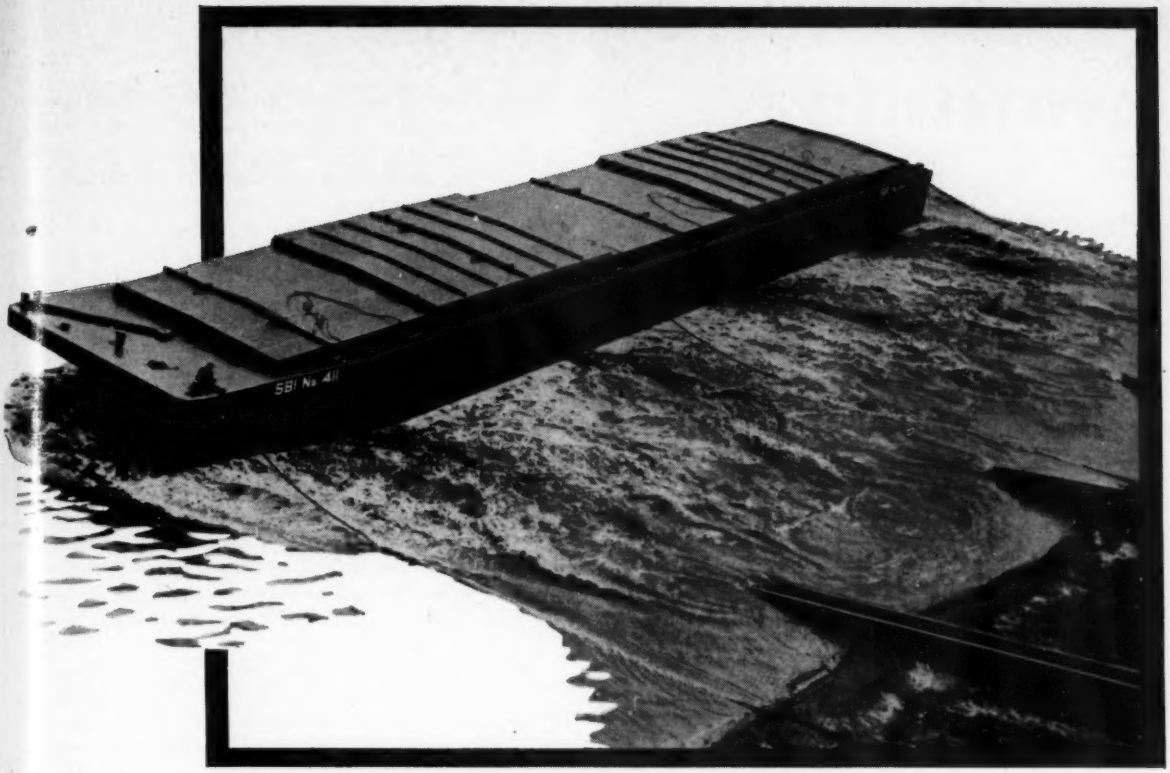
Beaumont Newhall, Curator of the George Eastman House, Rochester, New York, gave a lecture on "The Influence of Optics on Photographic Vision." Richard Tousey, of the Naval Research Laboratory, gave a paper on the optical problems of the satellite to be launched next year. The satellite will be difficult to see with the unaided eye, the best chance being during twilight. Telescopic observations will also be difficult, mainly because the satellite will cover about one and one-half degrees per second.

N. J. K.

E. M. HOMMEL ELECTED OFFICER AT PENNSYLVANIA CERAMICS ASSOCIATION

At the Pennsylvania Ceramics Association board of directors meeting held recently in Pittsburgh, E. M. Hommel, president of the O. Hommel Company, Pittsburgh, Pennsylvania, was elected first vice president.

In his capacity, Mr. Hommel will take over the duties of general chairman of the many important committees involved in the betterment of the growing ceramics industry in the Pennsylvania State area.



Joining the Olin Mathieson fleet

Here is one of the six new 1400-ton barges which will serve users of Mathieson chemicals. These 195-foot, all-steel barges are weather tight; the rolling hatch covers can be moved to expose 50% of the hold for easier loading and unloading.

The efficient use of water, rail and highway transportation helps customers get the full benefit of Olin Mathieson's multi-plant facilities. Whether you order by barge, car, truck, or drum, Olin Mathieson's experience with the logistics of the chemical process industries will enable you to buy to better advantage. Call your Olin Mathieson representative for complete information.

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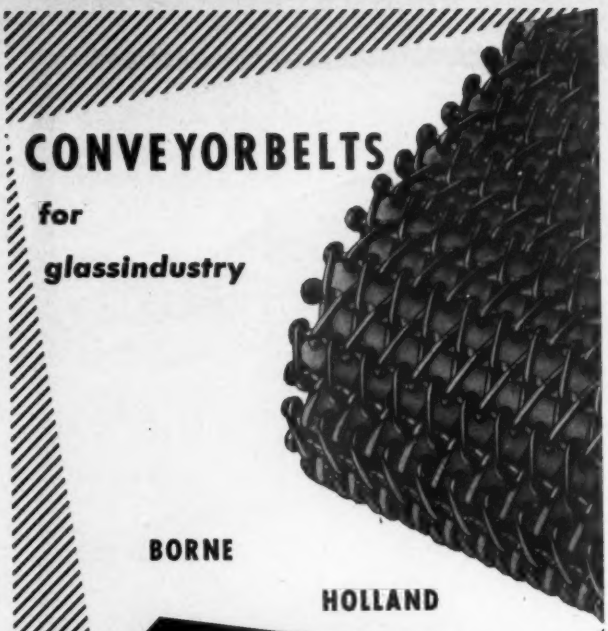

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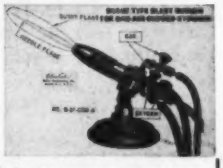

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President

Research Digest . . .
(*Continued from page* 680)

In the light of the accumulated data, and if a ternary system be postulated, the paths of solidification may be approximated and something of the relation of structure to crystallography and composition may be learned.

If the mechanics of solidification are traced, it is found that a thin shell forms at the bottom and four sides while the block is being poured; this shell is only a few millimeters thick, and as the rate of cooling was rapid, the crystals are small and compact. As soon as the block is poured a temperature gradient is established, and since crystallization is still rapid the primary chrome-corundum crystals are somewhat skeletal at areas just above the skin of the block. The rate of crystallization now becomes somewhat retarded, so that primary chrome-corundum crystallizing in the quite large residual liquid, partly settles and forms the dense area towards the center of the block. This phenomenon is similar to the fractional crystallization familiar to chemists, and is exactly of the same nature as the sinking phenomenon so common in igneous rocks. This dense section generally is placed toward the inner face of the tank and is particularly effective against glass corrosion.

The last material to solidify is in the very center and since this remains liquid the longest, chrome-corundum crystals tend to grow large, but they are intergrown with the spinel phase, which in turn contains some well-dispersed second generation chrome-corundum. There is no interstitial glass, the titania and silica being either absorbed or included.

The variation in microstructure in Type K is chiefly a matter of crystal size which in turn is a function of rate of cooling.

From this study it was concluded that: (1) Fused cast refractories consisting of a single phase of beta alumina (Type H) are uniform in structure and chemical composition. In order to have maximum uniformity of structure in fused cast crystalline bodies, the condition of having a single solid phase material is a desirable one and to have a high density and minimum porosity, the density of the liquid and solid phase should not be too far apart.

(2) Two phase fused cast crystalline refractories, such as type MH, form dense granitoid type bodies, when their solidification characteristics are those of rapid crystallizing crystals (analogous to metals in this respect), and the volume change from liquid to solid is small. The two crystalline phases should have the solidifying characteristics of a binary eutectic in order to avoid segregation.

(3) "Type K fused cast high alumina refractory is an example of a high alumina composition in which a primary solid solution phase separates out of a liquid over a short range of temperatures while crystal growth tends to increase toward the center of the block, the resultant refractory has the reasonably dense structure required for glass and slag erosion resistance."

• James S. Anderson, general sales manager of the Tubular Products Division, The Babcock & Wilcox Company announced the recent appointment of J. N. Rogers as sales representative in charge of the St. Louis District office.

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Ohio Manufacturer of Clear Glass	B&W 80 Firebrick in port construction, regenerator arches and walls, and top 8 to 10 courses of checkers. B&W Juniors in wall type checkers. B&W Allmul burner blocks.
Ohio Manufacturer of Container Glass and Borosilicates	B&W Dense 80 and Junior Firebrick in checkers. B&W Dense 80's in burner block necks and B&W Juniors in ports.
Pennsylvania Manufacturer of Container Glass	B&W 80 Firebrick in ports, regenerator arches and walls as well as top 10 to 14 courses of checkers.
West Virginia Manufacturer of Glass for Fluorescent Lamps	B&W Junior Firebrick in checkers and ports.
Kentucky Manufacturer of Glass for Bulbs	B&W 80 Firebrick in ports, and B&W Junior Firebrick in checkers.
West Virginia Manufacturer of Plate and Window Glass	B&W 80 Firebrick in ports and regenerator crowns.
Pennsylvania Manufacturer of Container Glass	B&W Allmul Firebrick used in complete refining end.

PROPERTIES OF B&W HEAVY FIREBRICK

	B&W ALLMUL	B&W 80	B&W JUNIOR
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Fusion point, F	3335	3190	3173
Hot load strength, % deformation, 25 psi, 1½ hours	Less than 2% @ 3050F	Less than 1% @ 2640F	Less than 2% @ 2640F

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GCMI EXHIBITING OLD JARS AND BOTTLES

Glass containers in rare sizes, shapes and colors are featured in the 1750-1900 collection now on permanent exhibition in the lobby of the New York headquarters of the Glass Container Manufacturers Institute.

Assembled by Helen McKearin from the world-famous George S. McKearin collection of American bottles and flasks, the GCMI collection includes such interesting old-timers as a granddaddy of today's ketchup bottle. Of aquamarine color glass, blown-molded in one of the graceful "Gothic" patterns, this hexagonal container was called a "pepper-sauce" bottle and used for sauces, syrups and vinegars a century ago.

Elder of the collection is a sturdy "black glass" wine bottle, free-blown, and ready for use about 1760.

A brilliant green nursing bottle, certain to startle a 20th-century infant, evidently suited the nursery set of the 18th and early 19th century. Pattern-molded in 12 vertical ribs and then blown and finished, this colorful glass container could be used as a pocket bottle by baby's father.

Medicine bottles, whose protective properties have long been recognized by the pharmaceutical profession, are well represented in the GCMI collection. One bottle of this group effectively forestalled price-cutting by its blown-molded inscription: "Jn. Moffat/ New York/Phoenix Bitters—Price $1."

A brilliant clear green Pitkin flask offers attractive proof of the durability as well as beauty of glass containers. Double dipped, pattern-molded in broken swirl ribbing (32 ribs), this flask was made about 1815-20, probably at the Keene-Marlboro-Street glassworks at Keene, New Hampshire. Another distinctive flask, a "sunburst" in brilliant olive amber, was blown-molded about 1815-30, probably at the same glassworks.

Vivid examples of very rare color in the GCMI collection include an opaque "Sandwich" paneled bottle in light blue; also similar bottles in rare shades of amethyst and light blue-green. Blown-molded in 12-sided form in the mid-19th century, these bottles were used for cologne, perfume and toilet waters.

An aquamarine "Lion" perfume and cologne bottle, believed to be the "Lion" type advertised by New Jersey bottle makers in the 1840's and 1850's, is a decorative and well-designed piece. A graceful "Ohio Swirl" bottle in brilliant amber is one of the types said to have been used in the early 19th century as bar bottles and decanters as well as in packaging liquors.

Lafayette's profile portrait, plus his signature in facsimile, distinguish a preserve jar, made about 1861 and considered rare. To decorate a perfume bottle of about the same period, glass is blown in a mold intricately cut to simulate a wickered demijohn.

Other interesting examples of the artistry and serviceability of glass containers include bottles for bitters, soda, pickles, blacking, liquor, beer, mustard, and ink.

• George P. MacNichol, Jr., president of Libbey-Owens-Ford Glass Company, has been elected a director of the Federal Reserve Bank of Cleveland to take office on Jan. 1, 1957. His nomination was sponsored by 33 member banks of the Fourth Federal Reserve District, comprising Ohio, and parts of West Virginia, Kentucky and Pennsylvania. He will be a representative of industry on the board.

WE SLICE BOTTLES

TO MAKE SURE COLORS "FIT"

Unless an ACL color "fits" a glass bottle properly, harmful stress can make the container unsafe for pressure beverages. To prevent such stress, Drakenfeld technologists use the most modern laboratory equipment and facilities to measure and study coefficients of expansion.

Even before an ACL color is created from a glass flux, the expansion compatibility of the flux itself is checked against that of a ring section from a bottle like that on which the color will ultimately be fired. Every color developed undergoes similar tests. After sample bottles are decorated, ring sections cut from them are studied under a polarizing microscope to make certain no strains weaken the bottle.

Such thoroughness is indicative of what Drakenfeld technologists do to solve your glass decorating problems. Drakenfeld ACL Enamels are made to "fit"—and give you the advantages of improved alkali resistance, better workability, greater acid, sulphide, chip-and-scratch resistance, and lower firing temperatures. Samples are yours on request. Write today.

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Index of THE GLASS INDUSTRY for 1956

A

Abrasives Used in Grinding of Glass, Grain Size of *Apr. p.* 206

Acid Base Relationship in Glass Systems—A New Acid-Base Concept Applicable to Aqueous Systems, Fused Salts, Glasses and Solids Part I, *May p.* 264; Part II, *June p.* 325

Acid Base Relationship in Glass Systems—Development of an Oxygen Electrode for Measurements of Acid-Base Properties of Glass *July p.* 381

Acid Base Relationship in Glass Systems—Application of the Oxygen Electrode in Galvanic Cells with Glasses of Different Composition *Aug. p.* 437

Adhesion to Glass, Atomistic Approach to the *Feb. p.* 71

Adhesion, Wetting Phenomena—a Means for Determining *Apr. p.* 201

Alumina During Firing, Effects of Various Mineralizing Agents in Promoting Recrystallization in Mixtures of Clay and *May* p. 274

Alumina Refractories, Petrology of Fused Cast, High *Dec. p.* 680

A.S.G.S. Holds First Symposium at Corning (American Scientific Glassblowers Society) *July p.* 386

Analysis of Glasses and Glassmaking Materials, Rapid Methods of *June p.* 334

A New Look at Flow in Glass Tanks *April p.* 191

Aqueous Systems, Fused Salts, Glasses and Solids, A New Acid Base Concept Applicable to Part I, *May p.* 264; Part II, *June p.* 325

Atomist Approach to Adhesion to Glass *Feb. p.* 71

B

Basic Regenerator Refractories *Feb. p.* 89

Beverage Bottles by Silicones, Surface Protection of *Apr. p.* 195

Breakage Studies of Glass Bottles Under Internal Hydrostatic Pressure, Part II, Investigations of Stresses in Glass Bottles Under Hydrostatic Pressure, *Oct. p.* 566

Belts in the Glass Industry, Woven Wire Feeder *Aug. p.* 444

C

Calculation of the Relative Amounts of Ferrous and Ferric Oxides in Glass from Its Light Transmission *Oct. p.* 562

Chemical Endurance of Zirconia Glasses *Oct. p.* 561

Clay and Alumina During Firing, Effects of Various Mineralizing Agents in Promoting Recrystallization in Mixtures of *May p.* 274

Color of Soda-Lime-Silica Glass, Effect of Various Iron Compounds on the Transmission and *May p.* 257

Combined Approach to Better Forehearth Control *May p.* 262

Comparative Tracer Tests on Container and Window Glass Tanks—Part I, *Feb. p.* 71, Part II, *Mar. p.* 142

Construction Record on Huge Factory Expansion, L-O-F Achieves *Oct. p.* 558

Continuous Production of Corrugated Glass *July p.* 388

Cords in Glass, Part I, *Sept. p.* 491; Part II, *Oct. p.* 553; Part III. *Nov. p.* 613, Part IV, *Dec. p.* 668

Corrugated Glass, Continuous Production of *July p.* 388

Current Statistical Position of Glass *Jan. p.* 36; *Feb. p.* 91; *Mar. p.* 152; *Apr. p.* 212; *May p.* 275; *June p.* 335; *July p.* 394; *Aug. p.* 451; *Sept. p.* 505; *Oct. p.* 568; *Nov. p.* 629; *Dec. p.* 681

Cullet, Role of Glass Waste in Pot Composition *Feb. p.* 85

D

Decline in Japanese Glass Container Industry *Aug. p.* 446

Determination of Iron Oxide and Glass Raw Materials *Feb. p.* 85

E

Effect of Various Iron Compounds on the Transmission and Color of Soda-Lime-Silica Glass *May p.* 257

Efficiency of Russian Sheet Glass Plants *Oct. p.* 561

Electric Strain Gauge and Brittle Coating Studies, Part III, Investigations of Stresses in Glass Bottles Under Internal Hydrostatic Pressure *Nov. p.* 628

Etching of Glass Scales, Precision *Nov. p.* 620

F

Fabrication and Uses, Precision Glass *Dec. p.* 666

Factory Expansion, L-O-F Achieves Construction Record on Huge *Oct. p.* 558

Fall Glass Division Meeting—a review of papers and discussions *Nov. p.* 609

Feeder Belts in the Glass Industry, Woven Wire *Aug. p.* 444

Fibers, Temperature of Glass and Mineral *Apr. p.* 226

Fining of Glass by Introducing Additional Gases in the Melt, *Sept. p.* 496

Flow of Glass, Mold Surfaces and Their Influence on the *Mar. p.* 150

Flow in Glass Tanks, A New Look at *Apr. p.* 191

Forehearth Control, Combined Approach to Better *May p.* 262

Fourth International Congress on Glass *Sept. p.* 494

Fosterite Models, Photoelastic Studies of, Investigations of Stresses in Glass Bottles Under Internal Hydrostatic Pressure, Part I, *Sept. p.* 504

Furnaces, The Instrumentation of Glass Works *Jan. p.* 31

Furnaces, Refractories in Glass *July p.* 414

Furnaces, Thermal Insulation of Glass *Feb. p.* 85

Fused Cast High Alumina Refractories, Petrology of *Dec. p.* 680

G

Gases in the Melt, The Fining of Glass by Introducing Additional *Sept. p.* 496

Glass, A New Laboratory *Oct. p.* 562

Glass, Atomistic Approach to the Adhesion to *Feb. p.* 71

Glass Bottles, Investigations of Stresses Under Internal Hydrostatic Pressure, Part I, Photoelastic Studies of Fosterite Models *Sept. p.* 504; Part II, Breakage Studies of Glass Bottles Under Internal Hydrostatic Pressure, *Oct. p.* 566; Part III, Electric Strain Gauge and Brittle Coating Studies *Nov. p.* 628

Glass Conference Papers, Summaries of *Nov.* p. 622
Glass Container Industry, Decline in the Japanese *Aug.* p. 446
G.C.M.I. Meeting Hails Continued Growth (Glass Container Manufacturers Institute) *July* p. 379
G.C.M.I. Meets in Miami Beach (Glass Container Manufacturers Institute) *Jan.* p. 30
G.C.M.I. Meets in Phoenix, Arizona *Dec.* p. 665
Glass, Continuous Production of Corrugated *July* p. 388
Glass, Cords in Part I, *Sept.* p. 491; Part II, *Oct.* p. 553; Part III, *Nov.* p. 613; Part IV, *Dec.* p. 668
Glass Division—at the 58th Annual ACS Meeting *June* p. 315
Glass Division at the Annual CCS Convention *Mar.* p. 146
Glass Division Meeting, Fall—a review of papers and discussions *Nov.* p. 609
Glass Division Schedules Thirty Papers for Annual ACS Meeting *Apr.* p. 194
Glass, Effect of Certain Organic Liquids on Strength of *Aug.* p. 450
Glass, Effect of Various Iron Compounds on the Transmission and Color of Soda-Lime-Silica *May* p. 257
Glass Fabrication and Uses, Precision *Dec.* p. 666
Glass, Fourth International Congress on *Sept.* p. 494
Glass Industry—1955 *Jan.* p. 17
Glass Manufacture, Seeds and Fining in Optical *Jan.* p. 29
Glass, Mold Surfaces and Their Influence on the Flow of *Mar.* p. 150
Glass Ornamentation, Methods, Errors and Faults in *Feb.* p. 104
Glass Production, Solid State Reactions in Silicate Synthesis and *Mar.* p. 133
Glass Raw Materials, Determination of Iron Oxide and *Feb.* p. 85
Glass Rings as Fillers in Gas Scrubbers *Apr.* p. 226
Glass Scales, Precision Etching of *Nov.* p. 620
Glass Sheet Without a Debiteuse, Withdrawal of *Apr.* p. 204
Glass Tanks, A New Look at Flow in *Apr.* p. 191
Glass, The Fining of, by Introducing Additional Gases in the Melt *Sept.* p. 496
Glass, Theory and Practice Concerning the Use of Minor Constituents in *Aug.* p. 435
Glass Tubing, Vacuum Fabricated *June* p. 321
Glass Works Furnaces, Instrumentation of *Jan.* p. 31
Glasses and Glassmaking Materials, Rapid Methods of Analysis of *June* p. 334
Glasses, Chemical Endurance of Zirconia *Oct.* p. 561
Glasses, Colors of Platinum, Palladium and Rhodium in Simple *July* p. 393
Grain Size of Abrasives Used in the Grinding of Glass *Apr.* p. 206
Grinding of Glass, Grain Size of Abrasives Used in *Apr.* p. 206
Grinding, Wear Resistance of Metal Alloys in Glass *July* p. 388
Grinding Wheel of an Acrylic Plastic *Apr.* p. 205

H

Heat Content of Glasses and of Fused Salts, A Method of Continuous Measurement of High Temperature *Oct.* p. 549
High Temperature Heat Content of Glasses and of Fused Salts, A Method of Continuous Measurement of *Oct.* p. 549
Hydrostatic Pressure, Investigation of Stresses in Glass Bottle Under Internal, Part I, Photoelastic Studies of Fosterite Models *Sept.* p. 504; Part II, Breakage Studies of Glass Bottles Under Internal Hydrostatic Pressure *Oct.* p. 566; Part III, Electric Strain Gauge and Brittle Coating Studies *Nov.* p. 628

I

Instrumentation of Glassworks Furnaces *Jan.* p. 31
Insulation of Glass Furnaces, Thermal *Feb.* p. 85
International Congress on Glass, Fourth *Sept.* p. 494
Inventions and Inventors:
- Annealing and Tempering: *Mar.* p. 147; *Apr.* p. 207; *May* p. 270; *June* p. 332; *July* p. 390; *Aug.* p. 447; *Nov.* p. 624; *Dec.* p. 676
- Feeding and Forming: *Jan.* p. 32; *Feb.* p. 86; *Mar.* p. 147; *Apr.* p. 270; *June* p. 352; *July* p. 391; *Aug.* p. 447; *Sept.* p. 500; *Nov.* p. 624; *Dec.* p. 676
- Furnaces: *Jan.* p. 33; *June* p. 332; *Aug.* p. 447; *Nov.* p. 625
- Glass Compositions: *Feb.* p. 87; *Mar.* p. 148; *Apr.* p. 209; *May* p. 271; *June* p. 333; *July* p. 391; *Aug.* p. 448; *Oct.* p. 563; *Dec.* p. 677
- Glass Wool and Fiber: *Jan.* p. 33; *Feb.* p. 88; *Mar.* p. 149; *Apr.* p. 208; *May* p. 271; *June* p. 352; *July* p. 392; *Aug.* p. 448; *Sept.* p. 500; *Oct.* p. 563; *Nov.* p. 625
- Miscellaneous Processes: *Apr.* p. 224; *July* p. 397; *Sept.* p. 503
- Sheet and Plate Glass: *Jan.* p. 34; *Feb.* p. 92; *Mar.* p. 148; *May* p. 273; *Sept.* p. 501; *Oct.* p. 584; *Nov.* p. 626; *Dec.* p. 678
- Tube and Cane Machines: *Feb.* p. 88; *Apr.* p. 224; *May* p. 273; *July* p. 397; *Sept.* p. 502; *Nov.* p. 626

Investigations of Stresses in Glass Bottles Under Internal Hydrostatic Pressure, Part I, Photoelastic Studies of Fosterite Models, *Sept.* p. 504; Part II, Breakage Studies of Glass Bottles Under Internal Hydrostatic Pressure, *Oct.* p. 566; Part III, Electric Strain Gauge and Brittle Coating Studies, *Nov.* p. 628
Iron Compounds, The Effect of Various, on the Transmission and Color of Soda-Lime-Silica Glass *May* p. 257
Iron Oxide and Glass Raw Materials, Determination of *Feb.* p. 85

J

Japanese Glass Container Industry, Decline In *Aug.* p. 446

L

Laboratory Glass, A New. *Oct.* p. 362
L-O-F Achieves Construction Record on Huge Factory Expansion *Oct.* p. 558

M

Meetings:
- American Ceramic Society
  - Annual Meeting—*Apr.* p. 194; *June* p. 315; Glass Division *Nov.* p. 607;
  - Pacific Coast Meeting *Nov.* p. 613
- American Scientific Glassblowers Society *July* p. 386
- Canadian Ceramic Society *Mar.* p. 146
- Conference on Glass Problems *Jan.* p. 24; *July* p. 379; Glass Container Manufacturers (G.C.M.I.) Institute *Jan.* p. 30; *July* p. 379; *Dec.* p. 665
- International Congress on Glass *Sept.* p. 494
- Optical Society Meeting *Dec.* p. 675

Method for the Continuous Measurement of High Temperature Heat Content of Glasses and of Fused Salts, A *Oct.* p. 549
Methods, Errors and Faults in Glass Ornamentation *Feb.* p. 104
Minor Constituents in Glass, Theory and Practice Concerning the Use of *Aug.* p. 435
Mold Surfaces and Their Influence on the Flow of Glass *Mar.* p. 150

N

New Equipment and Supplies: *Jan.* p. 35; *Feb.* p. 90; *Mar.* p. 155; *Apr.* p. 214; *May* p. 276; *June* p. 345; *July* p. 395; *Aug.* p. 452; *Sept.* p. 506; *Oct.* p. 569; *Nov.* p. 630; *Dec.* p. 682

O

Optical Glass Manufacture, Seeds and Fining in *Jan.* p. 29

Optical Society Meeting (From a Glass Perspective) *Dec.* p. 675

Ornamentation, Methods, Errors and Faults in Glass Feb. p. 104

Oxygen Electrode for Measurements of Acid-Base Properties of Glasses, Development of an *July* p. 381

Oxygen Electrode in Galvanic Cells with Glasses of Different Composition, Application of the *Aug.* p. 437

P

Pacific Coast Regional Meeting—a review of Glass Division papers *Nov.* p. 619

Petrology of Fused Cast High Alumina Refractories *Dec.* p. 680

Photoelastic Studies of Fosterite Models, Investigations of Stresses in Glass Bottles Under Internal Hyrdostatic Pressure, Part I, *Sept.* p. 504

P.P.G's New Specialized Plant and Warehouse at Greensburg, Pa, *Feb.* p. 81

Platinum, Palladium and Rhodium in Simple Glasses, The Colors of *July* p. 393

Polish Papers of Interest to the Glass Industry: Translations *Feb.* p. 85

Pot Composition, Role of Glass Waste (Cullet) in *Feb.* p. 85

Polishing, Zinc Sulfate and Iron Sulfate in Glass *July* p. 388

Precision Etching of Glass Scales *Nov.* p. 620

Precision Glass Fabrication and Uses *Dec.* p. 666

Production, Solid State Reaction in Silicate Synthesis and Glass *Mar.* p. 133

Properties of Glasses, Development of an Oxygen Electrode for Measurements of Acid Base *July* p. 381

Protection of Malt Beverage Bottles by Silicones, Surface *Apr.* p. 195

R

Raw Materials, Determination of Iron Oxide and Glass *Feb.* p. 85

Recent Translations of Russian Papers of Interest to the Glass Industry *Apr.* p. 204; *July* p. 338; *Oct.* p. 561

Refractories, Basic Regenerator *Feb.* p. 89

Refractories for the Glass Industry, Recent Developments in Bonded Zircon *Apr.* p. 210

Refractories, High Alumina Petrology of Fused Cast *Dec.* p. 680

Refractories in Glass Furnaces *July* p. 414

Rhodium in Simple Glasses, The Colors of Platinum, Palladium and *July* p. 393

Research Digest: *Jan.* p. 35; *Feb.* p. 89; *Mar.* p. 150; *Apr.* p. 210; *May* p. 274; *June* p. 334; *July* p. 393; *Aug.* p. 450; *Sept.* p. 504; *Oct.* p. 566; *Nov.* p. 628; *Dec.* p. 680

Role of Glass Waste (Cullet) in Pot Composition *Feb.* p. 85

S

Seeds and Fining in Optical Glass Manufacture *Jan.* p. 29

Sheet Without a Debiteuse, Withdrawal of Glass *Apr.* p. 204

Silicones, Surface Protection of Malt Beverage Bottles by *Apr.* p. 195

Sixteenth Conference on Glass Problems at Urbana *Jan.* p. 24

Solid State Reaction in Silicate Synthesis and Glass Production *Mar.* p. 133

Strength of Glass, Effect of Certain Organic Liquids on *Aug.* p. 450

Stresses in Glass Bottles Under Internal Hydrostatic Pressure Part I, Photoelastic Studies of Fosterite Models, Investigations of *Sept.* p. 504; Part II, Breakage Studies of Glass Bottles Under Internal Hydrostatic Pressure *Oct.* p. 566; Part III, Electric Strain Gauge and Brittle Coating Studies *Nov.* p. 628 tion of Glass)

Statistical Position of Glass: (See Current Statistical Position of Glass)

Summaries of Glass Conference Papers *Nov.* p. 622

Surface Protection of Malt Beverage Bottles by Silicones *Apr.* p. 195

T

Tanks, A New Look at Flow in Glass *Apr.* p. 191

Tanks, Comparative Tracer Tests on Container and Window Glass, Part I *Feb.* p. 71; Part II *Mar.* p. 142

Temperature Heat Content of Glasses and of Fused Salts, A Method of Continuous Measurement of High *Oct.* p. 549

Temperature Resistance of Glass and Mineral Fibers *Apr.* p. 226

Theory and Practice Concerning the Use of Minor Constituents in Glass *Aug.* p. 435

Thermal Insulations of Glass Furnaces *Feb.* p. 85

Tracer Tests, Comparative on Container and Window Glass Tanks, Part I *Feb.* p. 71; Part II *Mar.* p. 142

Translations:
Polish: *Feb.* p. 85
Russian: *Apr.* p. 204; *July* p. 388; *Oct.* p. 561

Transmission and Color of Soda-Lime-Silica Glass, Effect of Various Iron Compounds on the *May* p. 257

Tubing, Vacuum Fabricated Glass *June* p. 321

V

Vacuum Fabricated Glass Tubing *June* p. 321

W

Warehouse at Greensburg, Pa., P.P.G's New Specialized Plant and *Feb.* p. 81

Wear Resistance of Metal Alloys in Glass Grinding *July* p. 388

Wetting Phenomena—a means for Determining Adhesion—*Apr.* p. 201

Window Glass Tanks, Comparative Tracer Tests on Container and Part I *Feb.* 71; Part II *Mar.* p. 142

Withdrawal of Glass Sheet Without a Debiteuse *Apr.* p. 204

Woven Wire Feeder Belts in the Glass Industry *Aug.* p. 444

Z

Zinc Sulfate and Iron Sulfate in Glass Polishing *July* p. 389

Zircon Refractories for the Glass Industry, Recent Developments in *Apr.* p. 210

Zirconia Glasses, Chemical Endurance *Oct.* p. 561